5. System Components

The social fabric approach requires the specification of all component elements. Without this kind of specificity, it will not be possible to know what the element is delivering.

6. Control and Regulation

Rather than attempting to determine a system by examining objects and elements alone, the SFM methodology makes control and regulation an integral part of the process. It does this by first laying out antecedents and succedents in the delivery process; one delivery perforce leads to another and so forth. Second, and more explicitly, real world control and regulation elements are integrated into the matrix as separate matrix rows and columns, and into the digraph as separate nodes. They include social belief criteria as well as technical and natural criteria. Many times it is social beliefs and technological requirements which must be changed in order to change the degradation of an ecosystem. Thus, they need to be integrated and their consequences must be identified, as they are in the digraph.

7. Hierarchy

In digraph literature, hierarchy is defined in different ways, and most graph theory definitions are not consistent with GSA. However, one application is consistent and can therefore be used to determine the system hierarchy using SFM digraphs.

Given a digraph set, for example the “English” set in Figure 19. it is clear that the system is made up of a full set of B, D, E, F, K, L, and P. Any other set within that set will be a subset to the full set, such as the set P, K, and L; and consistently, the set K and L is a subset of P, K, and L. This demonstrates system hierarchy which can be used to determine and specify the deliveries and constraints between the levels of the hierarchy.

8. Flows, Deliveries, and Sequences

The entire SFM approach is based on flows, deliveries, and sequences. Thus, as was stated above, they are emphasized in that methodological approach.

9. Negative and Positive Feedback

In some respects, the terms negative and positive feedback are misnomers. To assume a feedback, as opposed to a feedforward, assumes one part of the system is forward and another part is backward. That is true only in a one-directional growth system. As “feedback” is added, the system ceases to be one-directional and begins to become balanced. The digraphs designed above indicate that “feedback’ loops are only another term for element delivery.

If we return to Figure 19, we see that the "Roman" system has the most feedback among the elements, while the "Arabic" system has no major feedback cycles.

From a SFM analysis of a system, three needs become apparent, as can be seen from Figure 19. First, it is apparent that new information deliveries need to be established to, for example, deliver information on ecosystem impacts to producers, buyers. sellers, government agencies, consumers, and taxpayers. For example, in Figure 19 the government deliveries to 1, E, and P do not take into consideration the social cost of ecosystem mining. With the matrix we can go cell by cell for each row to determine which decision nodes need to receive new information. A second need which can be observed is the need for new material flows. For example. in Figure 19 we can see there is no delivery sequence to recycle natural resources back into the ecosystem. Third, a SFM analysis allows us to see where new regulation and control criteria and mechanisms need to be established.

10. Differentiation and Elaboration

The SFM approach creates a digraph for observing systems and a concomitant data base. As the system differentiates and elaborates, new elements will be added to the matrix and nodes to the digraph; new deliveries will be indicated in the relevant matrix cells and new corresponding edges to the digraph. By comparing the new matrix, digraph, and data base with the original, system evolutionary change can be observed and measured.

By observing the full system, it will be possible to determine whether there has been structural change or just a change in the delivery path due to equifinality. For structural change to occur, it is necessary for the control mechanisms such as rules, beliefs, and requirements to change. These can be monitored and noted throughout the SFM process. With new policies, statutes, and court decisions, new elements are added to the matrix rows and columns. With new technology, new criteria, rules, and requirements are added: for example, a certain ratio of labor to land. As technology changes, the matrix will allow us to see what new requirements must be met by what institutions, and thereby to anticipate changes in the social structure and natural environment.

11. Real Time

The SFM digraph is consistent with activity sequencing called for by real time systems. Traditional time concepts and clocks are not sufficient for the space-time coordination which is going to be needed to solve our social and ecological problems in the future. We need "to develop a timing system which is internalized to the relationship between events in a socially relevant cycle" [Parkes and Willis 1980:77]. Activity sequencing "puts social problems into a system, which is ideally timed by the succession of events relevant to that system, that is by social time. In other words, reference to

universal or clock time becomes secondary to the internalized timing which is defined by the nature of the activity sequence structure" [Parkes and Willis 1980:77].

A SFM digraph "can be used to represent the sequence of relations and the direction of deliveries among the components of the social system. Such articulation can be used to plan communication networks, or transportation systems, or pollution controls, or whatever needs to be coordinated in a timely manner" [Hayden 1987:1308-9]. Events and flows follow one another in an order prescribed by the system, "thus sequence is a part of temporal order: . . . frequency of events during a period of time is critical; thus rate is also one of the ways that time impinges on social behavior. For all these elements of social coordination the term timing is useful . . . timing is an intrinsic quality of personal and collective behavior. If activities have no temporal order, they have no order at all" [W. E. Moore quote in Parkes and Willis: 1980:76].

12. Evaluation and Valuation

The SFM is used to detail all the entities which contribute to a system. That contribution is the basis for valuing a system and its parts. As has been clarified, there is no common denominator which provides one measuring mechanism for a system. The relationships and entities of a system, especially a system such as an agroecosystem, call for an array of different kinds of measures in order to define and evaluate the system. With such an array, it will be possible to focus on the evaluation of alternative policy concerns. The idea behind the EMAP endeavor is to establish indicators to evaluate an agroecosystem. EMAP is currently considering a whole array of indicators to be used for evaluating agroecosystems which includes the integration of human agricultural systems and the natural environment to which they are connected. Currently under consideration in that array of indicators are the following: agricultural exports such as pesticides, sediments, and food contaminants; resource modifications like species diversity and land use patterns; sustainability indicators such as indications on tillage practices and soil organic matter content; contamination indicators like pesticide residues in soil, water, and animals, biomarkers, and heavy metal concentration: and socioeconomic indicators such as farm income and population shifts. Dollar income is included, but not as the measure: rather, as one of many indicators.

A SFM analysis provides a wealth of information for the valuation process. Valuation is about determining what is better and worse, what is improvement, and what is degradation. As systems philosopher Richard Mattessich has stated, "to answer the question of how to improve the system, one needs criteria for and measures of effectiveness" [Mattessich 1978: 290]. There are a number of socioecosystem criteria concerns and norms such as biodiversity and restoration which will be discussed next with respect to the SFM measure of effectiveness. The first is with respect to norms and control mechanisms of the system.

Norms and Control Valuation: "A system has a goal or purpose either (1) because the inner or mentalistic aspect of the system is developed highly enough so that norms emerge out of this system . . . or (2) because some norms are imposed. in one form or the other. from outside upon the system" [Mattessich 1978:289]. The SFM documents and shows the importance of both kinds of norms. As social and ecological systems develop, new entities with control properties develop to normalize relations and deliveries in the system; for example, social belief criteria and natural control mechanisms. In addition, policy control mechanisms are included as part of the system and included in the SFM description. Mattessich and others have stated that these norms and criteria are the most important entities in the system. Thus, their condition and ability to guide need to be evaluated.

If, for example, they are unable to work because of the paucity or abundance of deliveries, they are of less value. For example, the control mechanisms of an oceanic system may be misfiring because they are overwhelmed with an excess delivery of urban sewage. As another example, recent evidence indicates that farmers in Iowa have strong belief criteria to protect the ground water, yet they are polluting it through the use of farm chemicals because their ability to deliver consistent with their beliefs is hampered by the inadequacy of financial, educational, and institutional flows. The condition and welfare of the norms and control mechanisms are important, and their effectiveness can be evaluated through the SFM.

The SFM can be used to determine how effective are the normalization controls by measuring the system flows that result from those norms. How great the value of the controls is determined by the degree to which the system is functioning according to a normalized flow. Standard techniques can be used to determine the "goodness of fit" or deviation from the norm.

12.a. Biodiversity Valuation: There is a concern for biodiversity in ecosystems in terms of the number of species, the inventory of the species, and the redundancy through equifinality. The SFM approach provides information on all three. The species would be an element in the matrix in some cases, and in other cases a cell delivery; for example, a river delivering fish. In order to know either how much the species delivers to another element, or how much of the species is being delivered, it would be necessary to have information on the kind and number of species. Once the basic SFM and digraph are constructed, the computer can be instructed to list the species and sum their inventory. It will therefore be possible to value ecosystems with regard to biodiversity and to determine whether there are too many or too few of a species, consistent with the carrying capacity of the ecosystem.

It will also be possible to determine the degree of equifinality redundancy, as was explained above in the Equifinality section. If there are

more paths for maintaining species, the system is more valuable from a biodiversity valuation criterion point of view.

12. b. Stability Valuation: There has been considerable interest in stability valuation of two kinds. The first to be discussed below is the stability of the system due to vulnerability of the elements within. The second is with regard to vulnerability of the system as a whole.

With regard to the first, the SFM can be used to rank the most important relationships and "nerve" centers within a system. By valuing the importance of the centers within the system, system vulnerability can be ascertained. If the system becomes more vulnerable through the destruction of one node over another, then that one is more valuable than the other. The SFM can be used to measure the relative importance of the elements and. nodes within a system by adding all the l's in the rows and columns in the boolean skeleton matrix (Figure 9). The greater the number of l's in a row, the more deliveries that element is making to other elements. Or, stated differently. the more l's in the row, the more other elements are dependent on that element. The greater the number of l's in a column, the more that element is receiving from other elements. Others cannot continue to function (process deliveries) if that element cannot continue to receive.

While the greater centricity of a system gives the central node in a system more value, the greater centricity makes the system more vulnerable. There is literature to suggest that more diversified ecosystems are more stable. Following from that, it is possible to compare the stability of systems by comparing their degree of centricity in the SFM digraph. If a system is more centrally organized, it is more vulnerable, and therefore less valuable. This can be determined by counting the number of elements and nodes. If two systems are the same except that one has a few large nodes upon which the system is dependent, then it is less valuable.

12.c. Transformation Valuation: From the SFM data base, a normalized flow which must be maintained can be determined, and that normalized value can be used to evaluate alternative economic production projects which are being introduced to transform a socioecosystem. No new production project can be introduced without disrupting an ecosystem: thus, some of the normalized flows will have to change. However, by normalizing the flows in the SFM digraph and establishing a spectrum around that norm to establish how far it is safe for the system to deviate, different projects can be judged according to their "goodness of fit." The less the new project deviates from the normalized system, the greater its value. It may, of course, be decided that changes can be made in the original ecosystem, thereby establishing a new norm.

A simplified illustration is contained in Figure 20. Only a simplified digraph can be so illustrated in two dimensions. Assume a subsystem as contained in Figure 20 with 2, 3, 5, 7, and 11 representing system elements

Figure 20. Simple SFM Digraph

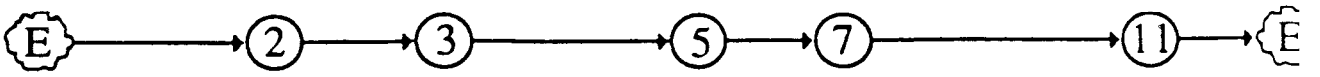


Figure 21. Necessary Level for System Feasibility

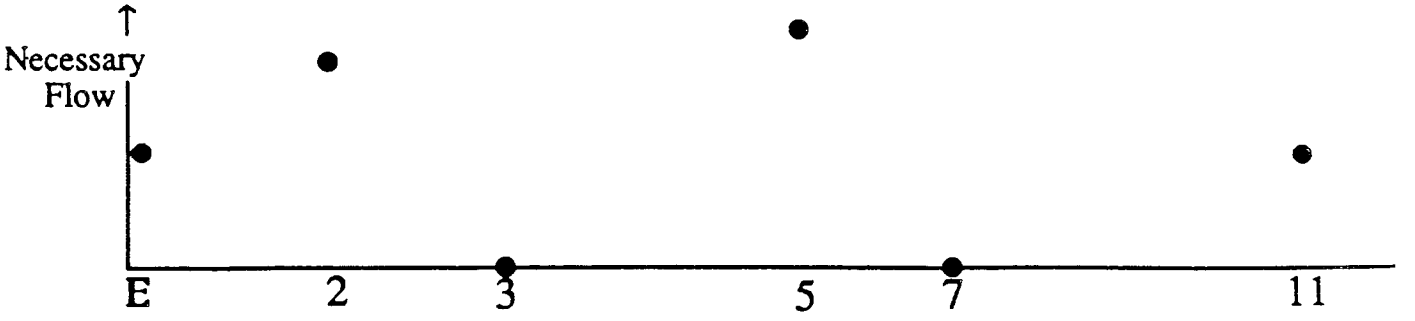
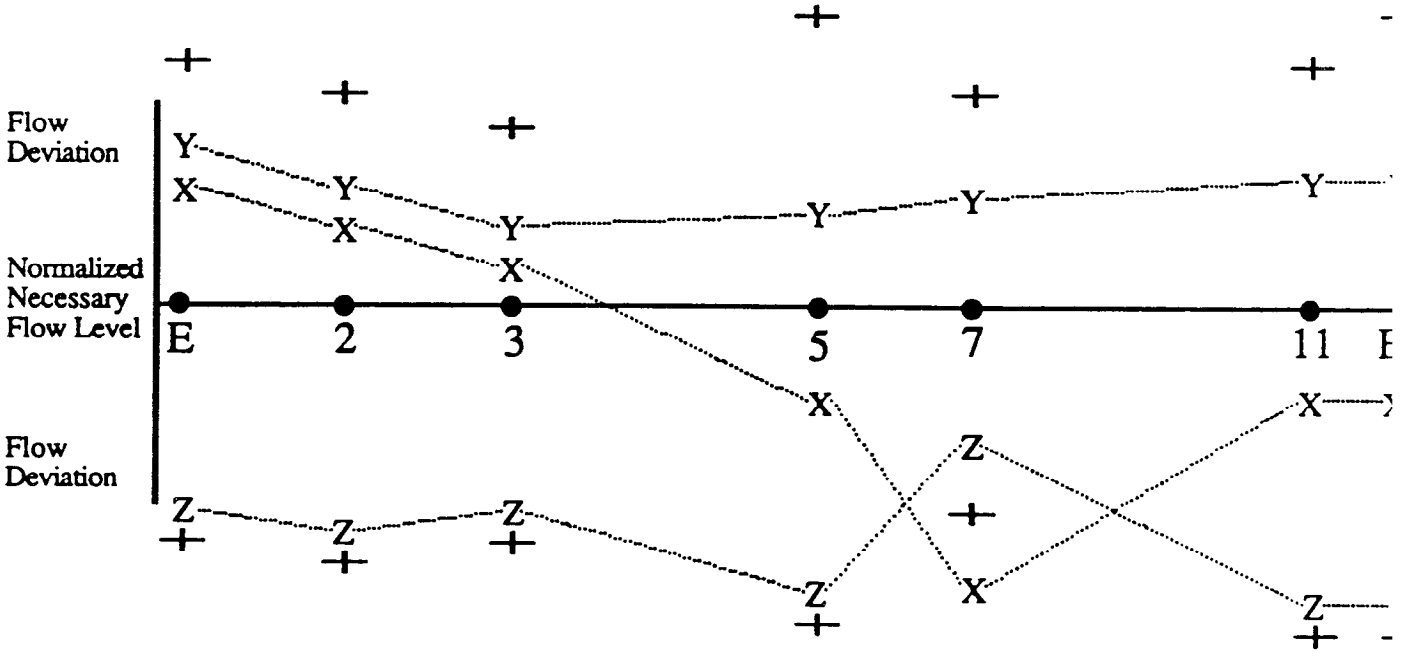


Figure 22. Level of Deviations of Alternate Programs



and E representing the environment. The distance between the digraph elements from Figure 20 can be collapsed onto an axis as in Figure 21 with the normalized flow level for each node indicated, including the environmental input and output necessary to keep the environment functioning. Each dot on the graph represents a different delivery level, and those on the axis are not numerical indicators: for example, criteria. The flow level from Figure 21 can be normalized along the axis in Figure 22, as indicated by the dots.

If there are two different characteristics or dimensions to be measured for each delivery, the axes above and below the normalized level are positive in order to determine how much a project's trajectory deviates from the normalized feasibility level. In all systems there is a spectrum of permissible deviation from the norm. The critical threshold level is the extreme extent of deviation allowable. It is indicated by ⊣⊢ in Figure 22. Some of these will be quality indicators, for example, in the case of criteria and requirements, and others will be quantity indicators. The quantity flow can be too great a surplus, as with excess pollution from an industry or animal flocks when a predator is removed: or too small a flow, as when the flow of a species in a food chain is decreased. Alternatives X, Y, and Z, represented in Figure 22, can be ranked according to their deviation from the normalized flow. This can be determined by the difference between the program trajectories and the system sequence axis, except in those cases where the trajectory penetrates the critical level represented by⊣⊢. This would eliminate X, even though generally it conforms most closely to the normalized system sequence axis. The idea is to fit a selected norm. represented by the horizontal axis, rather than to maximize a function from the axis. As is obvious, Project Y is the best fit, and therefore is evaluated to have the greatest value to the system.

It may, of course, be decided to change the system flows from the original. If so, the same procedure could be followed with a new selected delivery level. The SFM data base could be used to indicate the impacts of the new flow levels throughout the system. A complex digraph system cannot be displayed, as in Figure 22; however, the idea is the same. For each delivery upon which an economic project will impact, whether quantitative or qualitative, the normal delivery needs to be established and the project's deviation from it determined. If the project falls within the critical threshold, it is acceptable: if it best fits the overall flow levels, it is the most efficient. Every project has a multitude of impacts, and they should be considered in a systems approach to minimize transformation costs.

12.d. Restoration Costs: The establishment of restoration costs to restore a damaged ecosystem is not a case of valuation. It is an operational action to convert the damages into a budget sufficient for restoration. The July 1989 ruling in State of Ohio v. U.S. Dept. of the Interior on this subject is consistent with this view. The Court stated "restoration is the proper remedy for injury to property where measurement of damages by some

other method will fail to compensate fully for the injury. Congress' refusal to view use value and restoration value as having equal presumptive legitimacy merely recognizes that natural resources have value that is not readily measured by traditional means"[Ohio v. Interior 1989:456-57].

Restoration costs are not even necessarily market costs in the sense that the prices to be paid for the equipment, labor, and materials were established by a competitive private market system. Some prices are explicitly governmental through price regulation; others by indirect governmental impacts through subsidies and taxes; and others are charges by other government agencies to do the cleanup. In addition, many of the private sector prices are determined in an oligopolistic setting. Restoration costs are a matter of determining shelf prices to get the job done. A SFM digraph model of an ecosystem may be helpful in tracing the indirect impacts of a toxic or hazardous substance spill to help trace how the spill is delivered through the system, and therefore all the costs which must be undertaken for restoration

12.e. Restoration Valuation: Restoration valuation is different than restoration cost. The valuation aspects of system restoration can be completed with the SFM. First is the selection of the optimal restoration alternative. Restoration projects themselves can also change an environment. Thus. they should be judged as outlined above in the section on Transformation Valuation. The optimal alternative is the one which generates flows to return the ecosystem to its original purpose and structure without creating other adverse deliveries outside the threshold level for the system.

The second valuation aspect of restoration is to minimize the use of resources in the cleanup. As explained above, the SFM offers digraphs to illustrate alternative paths which exist to accomplish the same purpose and maintain its capacity. Therefore, if one path is damaged and there is a redundancy of equifinality paths, it may be that the ecosystem will be able to fulfill its goal without utilizing as many resources. Secondly, the SFM, as explained above, provides means for boolean-generated hypothetical delivery paths. Some of those paths may appear feasible and viable, and therefore could be tested against other alternatives (as explained above) to determine if they are more valuable restoration alternatives.

If budgets are limited, ecological improvements can be ranked according to the valuation and concepts explained above. However, before they can be used, judgments will need to be made. For example, is the budget going to be divided among ecosystems or among important parts of ecosystems? SFM valuation methodologies are helpful, but basic decisions are still necessary from policy makers.

Comparison to Indicator Design Standards

Discussion regarding the nine standards for judging the relevance of the SFM measurement indicators have already been covered in part. in the section just completed, so the comments here will be brief.

1. Consistent with Problem: The SFM is generating a data base specifically dealing with the system of interest.

2. Not Numerical Form: Not all the SFM data is in numerical form. It also includes qualitative indicators.

3. System Quantification: The SFM is designed to express a particular system consistent with GSA.

4. Aggregation: Aggregation within the SFM is consistent with measuring a system.

5. Limiting: The SFM approach expresses the limits imposed on the system by criteria, requirements, and control.

6. Systems Characteristics: The SFM methodology articulates indicators for patterns, sequences, ordering, linkages, and relationships.

7. Integrated: Integration of elements is expressed through the measurement of delivery flows.

8. Non-social Entities: The SFM does include the physical and biological laws and theories and their interactions with technology.

9. Site-specific Ecology The SFM requires that delivery information be site-specific, because the level and kind of delivery depends on the geobased delivery and requirement elements.

V

DIRECT COST

The direct cost section will be briefer than sections devoted to other methodologies. The brevity does not indicate an assessment of inadequacy or irrelevance. It is because some of its aspects have been covered under SFM discussion, and because substantial literature details the procedures for determining direct costs, including the literature on bid procedures, fiscal capacity determination, and property appraisal. The knowledge base in those areas will be very useful in determining direct cost.

Direct cost means the "off-the-shelf" or “real-world” price and costs of buying goods and services to accomplish a project. It is most consistent with the price or cost we pay or expect to pay. Direct cost is not consistent with the idea of costs in a cost-benefit analysis, and it is not consistent with what economists usually mean when they speak of market prices or the market cost. Those conducting a cost-benefit analysis attempt to adjust real-world prices to correspond to what the prices and costs would be if there were a competitive market system. Direct costs reflect the consequences of subsidies, taxes, collective bargaining, oligopolistic prices. monopoly rents, government regulations, social customs, rent and price controls, tariffs, fair labor laws, court decisions, quotas, government incentives, and so forth. They are the costs that must be paid to acquire the resources to get the job done within the real-world system. They are quite consistent with what the U. S. Congress has stated to be the cost measure for restoration due to natural resource damage, as well as for determining use value and equifinality value. However, not all direct costs are monetary costs. IRS, for example, recognizes non-monetary incomes and costs.

Direct costs include numerous non-monetary and non-market systems. The various forms of economic structure and integration need to be considered in determining direct costs. The difference between markets and market systems may need clarification. There is evidence that for thousands of years societies across the globe have had markets where goods and services are exchanged, but seldom have those markets operated within market systems. Sometimes the markets have used money, and sometimes barter. Sometimes they have had set prices which are determined by tradition or a government authority. and in other cases the prices have been allowed to fluctuate. Markets are common; market systems are rare. Market systems are systems in which the activities in markets with fluctuating bargained prices determine what goes on in the remainder of the

economy. The institutions of supply and demand as they are affected by scarcity and wants determine production, resource use, and incomes in a market system. That kind of system does not operate in much of the world. Economic systems as diverse as those to be found in Iran and China and among the Bedouin tribes of North Africa use markets, but they are not market systems.

Three economic sub-systems are used to locate and categorize the economy. They, to the extent they are applicable to the particular case under assessment, relate to direct cost. The three categories are: exchange, redistribution, and reciprocity. They represent different ways in which the economy is integrated and organized, and in which decisions are made with respect to the use of resources, production of goods and services, and distribution of income.

Exchange systems are usually categorized as market and non-market exchange. The former has prices fluctuating according to supply and demand, while the latter usually has administered prices. This is similar to the distinction made above between market systems and markets. Both of these kinds of exchange institutions exist in the United States. and most of our markets fall between the two extremes of pure market and pure non-market exchange..

Redistribution means the movement of goods and services to the center and out again; it is therefore dependent on viable institutions of centricity, which means that there is an allocation center in the community. A system is categorized as redistributive if goods and services are collected into a center by virtue of custom, law, or ad hoc central decision. In some cases it is accomplished by the physical movement of goods to inventory centers for later distribution; at other times it is not physical, especially in the case of intangibles, but an appropriational redistribution with regard to the rights of disposal. Economies at very different levels of affluence and technology have depended on integration through redistribution. They include the simple Tasaday gathering tribe of the Philippines as well as the modern governmental sector which collects taxes and production to the center; and then redistributes goods, services, and payments back out to various groups. The vast role of government in the U. S. economy makes redistribution institutions important to any economic issue.

Reciprocity means the production and movement of goods and services among different groupings within a society. The different groups, for example. kinship groups, have social obligations to respond to common symbols with definite institutional enforcement of the expected response through law or custom. Simple reciprocal behavior based on the consensuality of neighbors is not reciprocity, because it is not organized, integrated, and enforced by institutional arrangements. Numerous groups can be involved in a system of reciprocity and groups need not reciprocate with one another directly, but through a corresponding member of a sequence of other groups. Although economic integration through

reciprocity plays a major role in some complex societies. it has a relatively minor role in the U. S. economy compared to exchange and redistribution. However. kinship groupings are important for some economic integration and decisions.

Various simpler societies have been integrated exclusively by one of these subsystems. In modern complex societies, all three usually exist, sometimes side by side. For example, an industry may deliver a large percentage of its product through a cartel arrangement (reciprocity) and the remainder by selling on the open market (exchange) to other industries and to government (redistribution).

The various forms of economic integration need to be considered in determining direct costs in cases of natural resource restoration and establishing use value. With restoration, goods and services might be obtained through all three subsystems. Likewise, in determining use value, producers in all three subsystems may have lost the use of natural resources because of natural resource damage.

Comparison to GSA Principles

Direct costs are the measurement of the flow of goods, services, and resources necessary to pay for restoration projects. As such, they are not intended to explain a system. Instead, they are a measurement within a real-world system.

1. System Defined

The direct costs are necessary to help define any system that includes the economy as part of its bounded entity. The flow of direct costs serve as a linkage between system elements.

2. Openness

Open systems which are “price-takers” from an external environment or which must pay for goods or services from an external environment have use for direct cost information in order to understand the relation between the system and its environment.

3. Nonisomorphic

Direct cost determination is not dependent upon isomorphic assumptions, Some of the direct costs are dependent on highly organized oligopolistic industries in which the prices of goods are delivered from oligopolistic decision making. Others are highly influenced by government regulations or government price controls. The direct cost information is a reflection of the system.

4. Equifinality

Direct cost information is not intended to find the alternative paths available in the system. However, in attempting to determine the cost effectiveness of various paths to restoration, the direct cost information is important.

5. Components

There is no attempt to define system components through direct cost techniques.

6. Control and Regulation

Direct costs serve as one of the delivery-type controls in a system. Direct costs represent a delivery from one element to another and as such they influence subsequent behavior. This approach offers no assistance in defining the second type of delivery control.

7. Hierarchy

Direct cost information is useful in defining the information flow between levels, and thus in defining the structure of a system hierarchy.

8. Flows. Deliveries. and Sequences

Direct costs are flows, usually monetary, in payments for flows of goods and services or the factors necessary to produce goods and services.

9. Negative and Positive Feedback

Direct cost information can serve as negative or positive feedback. Generally the argument is made that direct costs are not high enough to reflect the ecological damage from the production and consumption process. Thus, they provide a positive feedback for growth and decay. They can also serve as positive and negative feedback in the determination of restoration processes if a cost-effectiveness criterion is being utilized. High direct costs of a restoration alternative would be a negative assessment of that alternative.

10. Differentiation and Elaboration

As a socioecological system differentiates, there will be more flows of direct costs, more kinds of payments. more payment paths, and greater complexity of the payment network. Direct cost data collected for today's economy will not contain differentiation and elaboration information. Future expected direct costs should be calculated consistent with future expected elaboration.

11. Real Time

Direct costs are usually a real time system. The payments are made to fit the flow needs of the system.

12. Evaluation and Valuation

Direct costs are not, as stated earlier, direct measures for valuation except to the extent that they make a contribution to system welfare like all other flows. Monetary costs are not equivalent to value and, as Christian Leipert has shown, the common practice of summing all direct costs into a GNP figure does not measure welfare. Leipert calculated the system's direct costs, such as occupational disease and environmental damage, that are associated with economic production, and subtracted those costs out of GNP. [Leipert 1986 and 1987].

Comparison to Indicator Design Standards

Direct cost will next be compared to the indicator design standards.

1. Consistent with Problem: Direct cost is consistent with the problem of determining the flow of dollars necessary to acquire and allocate resources for a particular use. It can be collected consistent with the industrial structure in which the resources are being acquired.

2. Not Numerical Form: The vast majority of direct cost data will be in numerical form to include, as stated above, in-kind calculations.

3. System Quantification: Direct cost is not designed to express a system. However, it is consistent, if utilized properly, with expressing some of the flows.

4. Aggregation: As stated above, direct cost can be added consistent with determining a budget, but should not be added for an evaluation measure.

5. Limiting: Direct cost is not an indicator of system limits and thresholds.

6. Systems: Direct cost is not designed to articulate patterns, sequences, or ordering. Direct payments are one system linkage.

7. Integrated: Direct cost does not attempt to integrate ecological conditions, institutions, and organisms into a whole.

8. Non-social Entities: Direct cost does not include measures to specify physical and biological laws and their interactions with technology.

9. Site-Specific Ecology Direct costs need to be, and can be, site-specific but do not contain ecological detail.

VI

CONTINGENT VALUATION METHOD AND TRAVEL COST METHOD

The contingent valuation method (CVM) and travel cost method (TCM) are covered together in this section because both attempt to establish market valuation through survey techniques. Both methodologies attempt to place a market valuation on the natural environment not included in market exchange.

Several market type methodologies have have been designed to value non-market goods. These methodologies have a common foundation. The fundamental assumption is that the value of all goods can be expressed in money equivalent terms and that value is based on a good's utility to humans. If humans do not determine a use or exchange value for a good, then its existence is inconsequential. This assumes that all goods are created to serve man. This distinction becomes critical in valuing the natural environment. Once the overarching assumption is made that the basis for valuation is for humans, a number of assumptions follow. Many of the assumptions will be discussed below. Three basic ones are: that utility functions exist; that a utility function exists that can value non-market goods in rank order: and that these value rankings can be empirically identified with regard to the travel cost method (TCM) and contingent valuation (CVM) of valuing non-market goods.

Contingent valuation is defined as "any approach to valuation of a commodity which relies upon individual responses to contingent circumstances posited in an artificially structured market" [Seller et al. 1985: 158]. Typically, this valuation methodology is used in situations where exchange value cannot be established through a market process. Thus, there is no price associated with these goods. The CVM utilizes a direct questionnaire approach to solicit individuals' responses that purport to reflect each individual's valuation of a non-market good. The questionnaire attempts to simulate a hypothetical market for the good in question where the respondent indicates either willingness to pay (WTP) or willingness to accept (WTA) compensation for the non-market good [Bishop and Heberlein 1979:926].

There are three primary issues surrounding this technique which create potential problems. The first is the operationalization of a utility

function for estimating value. The second issue is the hypothetical nature of soliciting value rankings. The third issue is the question of validating the resulting data. The validation issue is one of determining if the questionnaire measures what it purports to measure. Richard Bishop and Thomas Heberlein reviewed the preliminary empirical results of their goose permit study and suggested, "when summed together these potential problems are sufficient to justify considerable skepticism about the accuracy of the resulting values estimates" [Bishop and Heberlein 1979:926]. These sentiments are also reflected by Seller et al. in their recreational boating study. They concluded that the CVM had problems with producing nonnegative demand curves and negative consumer surplus [Seller et al. 1985:172 & 75]. In other words, the contingent valuation responses to their open format questionnaire implied the respondents were willing to pay less for ramp fees than they actually spend during the recreational season.

The TCM attempts to estimate demand functions for non-market goods based on the notion of indirect costs. The method has been extensively used in the valuation of recreational sites [Seller et al. 1985: 157]. The demand functions are estimated by using travel costs as a surrogate for value. In defining indirect costs, several significant assumptions are made. First, it must be determined what are substitutable sites or activities. Second, a decision has to be made on an appropriate value of time to travel to the site. Third, decisions have to be made on how to allocate the value of a site between its ambience and its various other activities. There are also a number of data requirement problems related to this approach. The editors of the book Valuing Environmental Goods conclude that the problems in specification and data collection with the TCM "result in the dispelling of what was once regarded as the TCM's greatest potential strength: appealing to the notion that visitor values must equal or exceed travel costs" [Cummings et al. 1986:95]. It appears that the outcomes of the TCM are a function of the assumptions made.

Measurement models are designed to reflect a theoretical construct. Before measurement techniques such as CVM and TCM can be understood. the theoretical construct they purport to measure must be understood. In other words, what does a regression with these variables actually measure? What are the demand functions that economists claim drive the market system? Do they exist for non-market goods as well? These questions will be addressed in the next section regarding consumer preference.

The hedonic price method (HPM) is not being covered in this report. However, since it is referred to later in discussions regarding the testing of CVM, it will be briefly defined at this time. HPM was introduced to split a good into its various attributes for the purpose of assigning values to particular attributes. Operationally in HPM, the commodity's market price is generally regressed against attributes in order to assign values to attributes. For example, a house has an overall function of shelter, but each house also has numerous attributes such as size, number of rooms, location,

style, lot size, neighborhood, and so forth. "Estimation problems abound in efforts to implement the HPM--to name but two: persistent collinearity between 'important' variables and extraordinarily low explanatory power in regression equations" [Cummings et al. 1986: 96].

Consumer Preference

The concept that individuals rank commodities derives from consumer preference theory. There are two specifications of the demand functions in valuing non-market goods. However. in discussions about the validity of estimating a price for non-market goods, there is rarely any mention of the appropriateness of using either Hicksian or Marshallian demand functions as the theoretical foundation for what the TCM or CVM purport to measure. Rather. the discussion of CVM in the literature surrounds the psychometric issues of demand artifacts, internal validity, and self-generating constructs [Heberlein 1979; Seller 1985; Thayer 1981]. The TCM struggles with specifying the model, given the data limitations, so that it remains consistent with theory [Desvousges, Smith, and McGivney 1983]. Thus, a comparison of CVM to HPM cannot provide evidence of the validity or accuracy vis-a-vis "true" value of CVM as a means of valuing public goods [Cummings et al.: 1986:96].

The problems of estimating demand functions are well known [Varian 1984: 142, and Majumdar 1975:40]. Thus, before determining the validity of these methodologies as a measurement technique. the theoretical construct of consumer preference will be reviewed; because if the construct that the instrument is trying to measure is inappropriate for estimating the value of non-market goods, then the results of TCM and CVM have little meaning.

The microfoundation of market demand is the theoretical construct of consumer preference. This construct is often referred to as consumer demand functions or "utility" functions. The utility construct develops axioms that represent how consumers value rank commodities in a market system. Confronted with a set of market prices and corresponding goods. the consumer can establish ex ante a ranking of preference for these goods based on the relative satisfaction the goods will yield to him. This ranking is known as the indifference map. To understand the nature of how an individual establishes this ranking, the axioms underlying the decision need to be reviewed. The axioms direct that consumer behavior is determined by logical necessity and not by the study of human behavior.

Neoclassical economics is highly axiomatic in that behavior described by neoclassical economics must conform to classical mathematical logic. Without this conformity, neoclassical economic modeling falls apart. Thus, a series of axioms are assumed about how consumers rank their preferences. The basic assumptions, which are relaxed in more advanced analysis,

illustrate the point that the assumed human behavior in the theory of the consumer is a highly artificial one. The axioms are as follows:

1. Completeness: For all x, y in X either $x \succeq y$ or $y \succeq x$ or both. This provides a complete ordering of preferences so that cycling of preferences does not occur. This axiom implies that two bundles can be compared.

2. Reflexivity: For all x in X, $x \succeq x$. Trivial.

3. Transitivity: For all x, y. and z in X, if $x \succeq y$, $y \succeq z$, then $x \succeq z$. This axiom is required if preference is to be maximized.

4. Continuity: For all y in X (x: $x \succeq y$} and (x: $x \preceq y$} are closed sets. It follows that (x: $x \succ y$} and (x: xcy) are open sets. This axiom rules out discontinuities.

5. Strong Monotonicity: If $x \succeq y$ and $x \neq y$ then x>y. This axiom simply states that more is preferred to less.

6. Strict Convexity: Given $x \neq y$ and z in X, if $x \succeq z$ and $y \succeq z$, then tx + (l - t)y $\succeq z$ for all $0 < t <$ 1. This axiom is the generalization of diminishing marginal return [Varian 1984: 112- 113].

These axioms purport to define consumer preference. From this set of axioms the familiar definition of utility functions emerges, with the characteristics of convex indifference curves and a single preference maximization, given a budget constraint. From the utility function the demand function is specified. In order to accept the notion of consumer preference as defined in the neoclassical model, all the axioms must also be accepted. These axioms are necessary and sufficient for demand functions to exist. If one of these axioms does not hold, then the notion of consumer preference cannot be determined. For example, the continuity axiom is necessary to rule out certain discontinuous behavior. In other words, in the ranking of bundles of goods, if bundles are merged into new sets, the strict ordering of the original set must be preserved. If offering goods to the consumer in different combinations causes the individual to reorder his preference, as often occurs through marketing, the axiomatic logic fails and no longer can optimal solutions be derived. Consumers must behave in a "rational" manner. "Rational" behavior is defined by the axioms. It is possible to construct reasonable scenarios where each axiom may be violated in practice by consumers making decisions to purchase. As Varian summarizes, "A utility function is often a very convenient way to describe preferences, but it should not be given a psychological interpretation" [Varian 1984: 112]. "It goes without saying that the axiomatic-deductive method has been in disrepute in recent decades. in all disciplines but mathematics and formal logic--and even here the axioms are often supposed to be a mere convention rather than necessary truth" [Rothbard 1979:20].

Proponents of this logical approach to model building argue that the model may be valid even if the assumptions are not. If the model approximates behavior. it is a legitimate tool of empirical analysis. [Friedman 1953:15]. However, consumer preference theory and the resulting demand curves also have significant deficiencies in explaining or predicting behavior.

Marshall, and later Hicks, made the first real efforts to empirically measure demand curves. Marshall approached the problem by specifying a demand function x(p, y) where demand is a function of price and income. This is a cardinal demand function where, in real terms, the consumer is able not only to value rank, but also to perceive the magnitude of value ordering. This implies that the demand function should be operationalizable. In other words, consumer utility is measurable in terms of money. Thus, it should then be possible to add utility.

However, there are two partial derivatives to this function; the price differential and the income differential In order to empirically identify the expenditure minimization problem. the function must be separable, thus implying that price and income are independent of each other. Therefore, the cross partials are zero. The separability requirement also implies that it is separable only up to a monotonic transformation. This severely restricts the form that the demand function may take. Human behavior is being constrained by mathematical requirements. The limitations and specification problems of this approach are such that "cardinalism in the 'additive' sense is therefore found quite untenable; while in the measurable-up-to linear-transformation' sense it is found completely inconsequential, except in an extreme situation, which is demonstrably unreal" [Majumdar 1975:135]. It should be noted that the TCM is usually specified as a Marshallian demand function [Seller et al., 1985:162].

A Hicksian demand function is an ordinal ranking demand function. Hicks operated directly from the utility function x(p,U). Instead of minimizing expenditures as Marshall attempted, Hicks sought to maximize utility. Hicks devised an indexing method to resolve the income substitution problems encountered by Marshall. Hicks assumed that he was able to create an index of all goods except one, the numeraire. In essence, this puts goods in what is called real terms. Or, price has no real impact on the consumer choice. Thus, in taking the cross partials their sum is equal to zero. In other words, Hicks resolved the substitution and income effect problem of optimization. He achieved this by monetizing the goods. He assumed that money is neutral (no effect) on real goods; therefore, there can be no income effect from price changes. However, there are significant deficiencies in trying to operationalize the Hicksian demand function. The first issue involved in determining the validity of this construct is the assumption that money has a neutral effect. The commodity that is chosen as a numeraire will affect the outcome of the ordering. [Arrow 1981:142]. Also, the comparison between two goods using a numeraire can only be made when "the markets clear." When this condition of equilibrium is not met, then money matters. [Arrow 1981:140]. Thus, changes in relative

prices and changes in numeraire will change the outcome of a Hicksian demand function preference ranking.

When an economist specifies a demand function in an econometric model, the type and form of the demand function is based on the above axioms rife with their conceptual difficulties. What is it these models have measured? The results, the economic parameters. are interpreted as the functional magnitude of the demand function. Thus, in a linear model, the weighted variables' contribution to the slope of the demand function account for a certain percent of the variation. The balance is attributable to random error. What one cannot say is that this estimation represents the demand function. The construct cannot account for the functional dichotomy of substitution and income effects or any of the nonmonotonic discontinuous complex behavior of people. In this approach human behavior is assumed to be monotonic and the econometric model will insure that the results conform to this requirement. The models force the data to fit a construct. What is important to gain from this discussion of demand functions is that they are incapable of modeling a complex system. Most economists agree that demand functions, if they do exist, have never been observed and probably never will. [Varian 1984: 1421

The debate on how to empirically measure demand functions continues. However, the debate does not question the basic axioms of consumer preference. The consumer preference axioms are integral to the neoclassical model's ability to construct optimization solutions. These derive the familiar conclusions that competition is a pareto optimal solution in the allocation of resources. However, these axioms do not yield usable operational rules for understanding real world phenomena. The problems encountered by functional form, restrictive assumptions, and naive beliefs on how people value rank goods leave consumer preference theory in the world of abstract constructs.

Other approaches for rank ordering preferences have attempted to overcome the specification deficiencies of demand functions. One approach that has received attention is called revealed preference. This set of axioms is the basis for CVM. In the event that a demand function cannot be revealed. it is still possible to generate comparative statics, both sign and ordinal ranking of goods. The general axiom of revealed preference is. if x1 is revealed preferred to x2, then x2 cannot be strictly revealed preferred to x1. x1 R x2 implies not x2 R x1. This is the observable consequence of utility maximization in that if data satisfies this axiom, the axiom is sufficient to meet the consumer preference axioms. Again, what is so important to note is the nature of deductive reasoning. If the data meets the revealed preference axiom, it can be deduced that because this condition is sufficient to meet the consumer preference axioms, the consumer preference axioms must be true. Unfortunately, theoretical work in the area of game theory has shown this axiom is invalid where strategies of a game theory type can be employed [Majumdar 1975:139]. Game theory is used where consumers perceive tradeoffs in their decision making. The

conclusion resulting from these game theory exercises is that the presence of choice need not reveal preference. The distortion of preference in observed choice suggests that preference may be sometimes revealed and sometimes distorted [Majumdar 1975:143]. In other words, interpretation of results cannot be made.

This uncertainty in solution implies that revealed preference fails one of the critical foundations of scientific analysis, the rejection of plausible alternative hypotheses. What other explanations also satisfy the revealed preference axiom? Have they all been scientifically rejected? If not, then the conclusion cannot be drawn that meeting the revealed preference axiom implies the existence of consumer preference as described by the consumer preference axioms. In contrast, the conclusion drawn by neoclassicalists is that if there exists a utility function that could have generated that behavior, then the demand function exists [Varian 1984:143].

Economists continue to search for a resolution to the problem of empirically identifying demand functions. Another significant problem yet to overcome is aggregation of consumer preferences. To derive a social welfare value, it is not possible to simply take the preference of one individual and multiply it by the number of persons in the society. This is Arrow's impossibility theorem. The impossibility theorem suggests that a society cannot have all individual preferences met and achieve optimal social welfare simultaneously. This is a problem that all public policymakers constantly confront in creating legislation. There are always winners and losers when new rules are imposed on society. The theoretical solution to resolving the impossibility theorem is that one of the axioms must be violated. The debate often surrounds dropping the pareto condition or the libertarian condition [Sen 1976]. If the transitivity axiom is dropped, it may be possible to have both optimization of individuals and of society [Mackay 1980:89]. But the transitivity axiom is a necessary condition of consumer preference theory.

Consumer Preference and Non-market Goods

The notion of using Hicksian and Marshallian demand functions for non-market goods adds further complications to identifying consumer preference. The TCM and CVM are two examples of attempting to measure the magnitude of value for non-market goods [Bishop and Heberlein 1979]. These approaches assume that people can and do make comparisons among all goods. If this true, then it should be possible to construct a demand function for these goods. It is assumed that people will value all normal goods in the same manner, or that the consumer preference axioms hold for all normal goods. Non-market goods do not have a price. Therefore, we do not know how people would respond to the pricing of these goods. Additionally, since demand functions have only been theoretically defined for those goods that have competitive markets, the notion that an indirect

price can be constructed will always leave the TCM and CVM methods open to controversy.

The very nature of public goods suggests that there is some attribute that cannot be captured by price. Thus, there will always be controversy whether TCM and CVM understate or overstate the relative real value. For example, when valuing the distance a person travels to visit a recreational site, does the greater the distance driven imply this non-market good is of greater value or does the person value the act of driving? What is the opportunity cost of travel time? These are questions that cannot be answered by aggregating the cost of gasoline and auto depreciation. Using a questionnaire format to answer these questions only raises new methodological questions concerning the validity of the results.

Psychometrics

Contingent valuation uses a questionnaire format to solicit a Hicksian preference value from individuals. The issue that needs to be addressed is whether this is an appropriate technique for determining non-market good valuation. This section will review the use of psychometrics and its techniques as a methodology for revealing individual preferences because it is important to understand the restrictions and limitations of applied measurement tools.

In psychometric theory there are very specific rules in questionnaire development and evaluation. These rules help insure that the instrument (questionnaire) measures what it purports to measure. One of the primary aspects of standardization requires that different people using the same instrument or an alternative instrument measuring the same trait should obtain similar results [NunnaIly 1978:3]. In the effort to standardize instruments so that repeatability is possible, a set of criteria is established that, if met, would provide reasonable confidence in the accuracy of the results. A complete guarantee can never be achieved because the consumer value for a non-market good is an unobservable trait. The two rules relevant to the CVM are that a questionnaire should have both reliability and validity. Because of the great potential for systematic error in the questionnaire approach, the instrument must be carefully tested to generate the maximum confidence possible that it is measuring what it is intended to measure, and that the instrument measures the trait accurately.

Reliability relates to the internal structure of the instrument. In a traditional instrument there are a series of questions that purport to measure the same trait. Thus, by checking the covariance of the responses to each question (Cronbach's coefficient alpha), one can identify whether or not the items covary. If significant covariance exists, the researcher can conclude that the items are measuring the same trait. It is assumed that any one question imperfectly measures the unobservable. Thus, a series of questions that imperfectly measure the trait are used so that an overall

image of the trait emerges. In the absence of using the reliability coefficient, an alternative check of reliability is the test-retest method. Here the questionnaire instrument is given to the same sample twice. After the initial survey, the questionnaire is given again several weeks later to see if the results are similar. There are serious defects in this approach that bias the reliability either upward or downward. Respondents may remember their responses from the first interview. or they may have changed their minds in response to an event occurring in the interval between interviews [Nunnally 1978:chap. 7].

The reliability of the CVM instrument is an open question. The nature of the bidding game precludes the ability to compute a coefficient alpha because the format is different from the traditional approach to measuring an unobservable. A test-retest method could be used replete with the problems inherent in the approach. However, it may provide some insight into whether the instrument is consistently measuring something. In most of the CVM studies. no significant attention is paid to reliability and therefore, it remains unclear if the CVM values generated are repeatable.

Instead, the researchers compare their results with alternative measures for the same population and the same non-market good. This verification technique does not resolve the issues of instrument reliability or accuracy. Cummings et al. argue that "all of the comparison studies undertaken to date have failed to carefully assess the accuracy either of the CVM used or the accuracy of the HPM (or TCM) used for comparison" [Cummings et al. 1986: 72].

The second consideration is the issue of validity. Several types of validity measures are used to verify whether an instrument is measuring what it purports to measure. The type of validity relevant here is construct validity. When construct validity exists, it improves the confidence that a correspondence between the abstract construct and the instrument exists. This is a core issue for the CVM. Construct validity is a necessary condition for theory testing. There are two aspects of construct validity that must be considered. The first is termed internal (trait) validity. This is essentially a term to identify if the construct is something different from other constructs. Essentially, this check tries to identify if systematic variance exists within the instrument and if this variance results in high correlations with other measures of the construct and low correlations with measures that the construct should not be related to [Peter 1981:207].

There are several approaches to establishing trait validity. One method that has received attention is the multimethod multitrait matrix. This technique attempts to identify what is termed convergent and discriminant validity. Convergent validity refers to two instruments with maximally different methods of measuring the same construct that are compared to see if their results converge. This is analogous to comparing TCM with CVM. The results should be similar if they are measuring the same construct. Discriminant validity refers to using the same method for

different constructs to determine if there is low correlation between the two constructs [Campbell and Fiske 1959].

This approach has been tried by researchers attempting to validate their results by comparing different approaches for the same construct. The TCM should yield similar results to the CVM. What the researchers in the area of valuation of non-market goods have failed to explore is whether or not using the same methodology for different constructs will result in similar values. Convergent and discriminant validity is necessary but not sufficient to validate the construct [Campbell and Fiske 1959: 106]. By failing to pursue all available means to verify the existence of a construct. "we all stand to drown in a mass of meaningless and potentially misleading junk" [Jacoby 1978:87].

The second form of construct validity that must be considered is nomological (lawlike) validity. This form of validity is based on the explicit investigation of the constructs and measures in terms of a formal hypothesis derived from theory. Nomological validation is investigating both the theoretical relationship between different constructs and the empirical relationship between measures of those different constructs [Peter 1982:207]. In other words, do the results of CVM confirm or contradict neoclassical theory? An affirmative answer is a necessary condition for the acceptance of the instrument. Given all the problems associated with trying to measure an unobservable except through hypothesized rules of correspondence, researchers conclude that a single study cannot validate the construct. In addition, it is not possible to conclude that the instrument is measuring what it purports to measure. This is essentially a form of external validation. "Even tentative acceptance of construct validity requires some amount of aggregation of results including both logical and deductive reasoning and a series of reliability and validity studies. . . . In fact . the most important implication of construct validation is the increased emphasis on the role of theory in validation" [Peter 1982:207]. Results which contradict theory should be carefully considered before accepting a measure. For example, the systematic error in CVM between the willingness to pay (WTP) and willingness to accept (WTA) measures is a case of unresolved construct validity. Willig [1976] argued that price changes and Randall and Stoll [1980] argued that quantity changes will have small income effects. Therefore, the substitution effect is observable. This conclusion is consistent with the theoretical constraints of the Hicksian demand functions so that WTP and WTA should be close for a given individual. The empirical results show that WTA is consistently larger, on the order of three to five times larger, than measures of WTP [Cummings et al.: 1986:35].

Another potential problem area in using questionnaires arises in the areas of demand artifacts and self-generated validity. Demand artifacts include all aspects of the experiment which cause the subject to perceive. interpret, and act upon what he believes is expected or desired of him by the interviewer. These artifacts can take the form of the "faithful" subject in

terms of providing answers that the subject believes the researcher wants, or the subject may take a negative or apprehensive role [Sawyer 1975:20]. The CVMs have attempted to reduce this effect by fully explaining the process to gain the trust of the subject and to discard what are perceived as protest bids. A protest bid is where the response of an individual is not consistent with his peers. The demand artifact also has been noted to be biased by what has been termed starting point bias. The subject perceives the relevant range of acceptable bids by where the bidding process begins and thus, the results are biased [Cummings et al. 1986:29-34].

A more serious problem in the hypothetical market technique is trying to measure a trait that does not already exist in long term memory. In the CVM, respondents are asked to value non-market goods in terms of dollars. It is likely that many of the subjects have never considered this exercise before. What may occur is that the questionnaire becomes directive in how the subject will respond. How the market is presented to the subject may determine his beliefs about the market. Having no foundation in his memory, the presented market becomes the basis for his decision [Feldman and Lynch 1988:424]. What is likely to occur after the interview is that the respondent may well further reflect on the exercise and change his mind. Again, CVM is aware of the information bias [Cummings et al. 1986:33], but proposes that a more complete education will reduce the problem. In the case of self-generated validity, the respondent must already have considered the valuation problem and drawn conclusions to avoid this type of bias.

While psychometrics and econometrics are similar, in attempting to test refutable hypotheses. there is one significant difference between them. In psychometrics, when the hypothesis is rejected. the researchers must consider whether the model is misspecified, the data is biased, or whether the construct is invalid. In econometrics. the construct (neoclassical foundation) is not questioned. The model may be misspecified. the data may be biased. or the sample may be inadequate. But hypothesis testing does not refute theory.

Empirical Studies

Travel Cost Method

The studies that have used the TCM have met with limited success. The problems with model specification and data limitation have biased the results so that the authors themselves have seriously questioned the validity of the conclusions. These studies are premised on the assumption that demand functions exist for non-market goods. Most of the studies use a Marshallian demand function. The results derived from these demand functions contradict the a priori predictions of the theory. The most common explanations given for the failure of these studies are two significant problems that confront the researchers. The first problem is the additivity of individual demand functions across sites and across activities to

arrive at an aggregate value. The second related problem is the severe data limitations that restrict the specification of the demand functions to keep them consistent with theory.

The Desvousges and Smith study on the value of water quality improvement for the United States Environmental Protection Agency (EPA) addressed the additivity and data limitations of this approach [Desvousges and Smith 19841. The results of this study were similar to an earlier study on water quality for the EPA conducted by Desvousges, Smith, and McGivney [Desvousges et al 19831. The conclusion of the 1983 study was that the explanatory power of the models used was not high [Desvousges et al. 1983: 1-10]. In the 1984 study, the authors attempted to improve the model specification of the demand function. As a validity check on their results, both Hicksian and Marshallian demand functions were specified in order to compare the results with theory.

Desvousges and Smith were forced to assume that the individual utility functions were equal for all individuals for each activity to resolve the additivity problem [Desvousges and Smith 1986:2-21]. The model requires monotonically separable demand functions but, due to data limitations, the authors were forced to assume an average mean user as a representative individual. The results were disappointing to the authors, who recognized the ad hoc nature of their assumptions [Desvousges and Smith 1986:2-28]. The crudeness of these assumptions seriously impacts the quality of the results.

In many instances the estimated coefficients did not agree a priori with the expected signs [Desvousges and Smith 1986:6-38]. Theory predicts that the Marshallian consumer surplus should be greater than the Hicksian surplus. The results contradicted theory [Desvousges and Smith 1986:7-21]. In an attempt to explain the results, the authors suggested that one significant contributor to the poor results was the use of the proxy variable, the mean user. The mean user included a mix of activities undertaken at a site, which is clearly inconsistent with theory [Desvousges and Smith 1986:6-38]. Additionally, the authors recognized that the variables specified, and the valuation assumptions made, make a substantial difference in the final benefit estimates [Desvousges and Smith 1986:8-24]. For example, each individual's valuation of the opportunity cost of travel time to a site is unknown. For some people travel time is perceived as a form of recreation, while for others it is time lost from work. These different valuations cannot be summed to some meaningful aggregate number. Thus, the researcher is forced to assume a value for travel time that is difficult to verify as accurate.

The Meta Systems report prepared for the EPA reached similar conclusions. [Meta Systems 1987]. They argued that the values generated should not be taken as important or precise in themselves. In other words, they are only approximations. They believed their calculated values were a result of their assumptions. The researchers believed that their

assumptions were conservative and therefore underestimated the true value of consumer surplus [Meta Systems 1987:1-25]. When comparing their TCM results with their CVM results, they failed to converge. The authors emphasized that these results underscore the limitations and shortcomings of these methodologies [Meta Systems 1987:6-44]. Finally, this group recognized that a major limitation of TCM is the lack of well-developed demand and supply curves [Meta Systems 1987:8-25]. The qualitative valuation will continue to insure that indirect cost measurement methods as a surrogate for value will remain underdeveloped.

The study by Brockstael, McConnell, and Strand for the EPA reflects the same concerns as the previous studies [Brockstael et al. 1988]. To the above list of concerns, their study adds the observation that restricting the model to the behavioral realm does not eliminate the uncertainty of future valuation as a potential source of modeling error. This uncertainty arises from environmental changes. When the environment is improved, people will change their valuation of visiting a recreational site [Brockstael et al. 1988:108]. The change in valuation cannot be captured within the context of a state-dependent utility function [Cummings et al. 1986:19]. The study concludes by suggesting that their measures should be considered as a first step towards a logical, albeit venturesome, task of estimating the benefits of improving the Chesapeake Bay [Brockstael et al. 1988:103].

Almost without exception. the authors using TCM for estimating consumer surplus encountered similar problems. The linear constraint on the Marshallian demand function is seen as artificial. The problem of nonadditivity of the utility function prevents the aggregation of consumer surplus across activities and across sites. The valuation assumptions on how to treat travel time, and the specification assumptions on the timing of when the visits occur, or on the number of visits, decreases the models' accuracy. The problem of estimating ex ante the expected value for a changed environment based on a state-dependent utility function questions the relevancy of TCM for explaining behavior under uncertainty. The lack of data results in misspecification of models. The magnitude of problems has led to TCM estimates that contradict the a priori theoretical expectations and cast serious doubt on the usability of the results. The editors of Valuing Environmental Goods conclude that, at best, the TCM accuracy is not better than plus or minus fifty percent [Cummings et al. 1986:100] or, stated differently, a TCM valuation can be wrong by over 100 percent.

Contingent Valuation Method

The studies using CVM for non-market good valuation have fared little better than the TCM studies. While similar problems exist for the CVM with respect to using utility functions, these studies introduce an additional source of potential error through the use of hypothetical markets and questionnaire format for data collection.

Whereas most of the attention in the studies using the TCM focused on the model specification and data limitation problems, the CVM studies focused on the problems of validity. These models, in contrast to the TCM. primarily used the Hicksian demand function that assumes utility remains constant when calculating monetary value for the non-market goods. This approach assumes away the additivity and separability issues but still contains the state-dependent problems.

In constructing a hypothetical market, the researchers are confronted with several tasks. The first is determining how to reveal the value of the goods. This involves educating the respondents as to the nature of the hypothetical market. To get the respondents to valuate these non-market goods, two approaches have been tried: WTP for using the good and WTA for not using the good. Theoretically, these two valuations should be approximately the same, assuming no income effect. The results of the research that used both approaches found that there was a significant divergence between the two measures. The WTP tended to undervalue the asset. while the WTA tended to overvalue the asset. The over and under valuation is based on the valuations in relation to each other, since there is no market valuation of the goods [Bishop et al. 1983:620]. In this sense, we do not know if the results of the two measures are under, over, or otherwise skewed. These results contradict the a priori theory that suggests that the two measures should be approximately the same given the predicted small income effect. This lack of convergence is particularly worrisome. The foundation of the utility function hypothesis is based on Willig's [1976] assertion that the two measures should be synonymous. To avoid this a priori contradiction, many studies "have not even bothered to estimate WTA" [Cummings et al. 1986:137].

A second primary issue in regard to the CVM approach is how to solicit the WTP valuation from respondents. Most authors have chosen a bidding process in which an initial price for the non-market good is offered. The respondent then indicates if the bid is low or high. The bid is then adjusted accordingly until the respondent feels his value on the non-market good is reflected. This method has received much analysis and criticism for what is called starting point bias. If the opening bid is too low, then it appears that this will bias downward the respondent's final choice of value. The converse is also true. If it starts too high, it will bias upward the final bid [Boyle et al. 1985:193]. The study done by Seller [1985] used both an open-ended format in which the respondent provided the valuation, and a closed-ended format in which the respondent answered yes or no to the stated value. What was revealing in this exercise were the substantially different results that occurred. The authors concluded that the open-ended format may be unreliable because of the negative consumer surplus and the low results this methodology produced [Seller et al. 1985:175]. However, an alternative explanation could account for the low results of the open-ended questionnaire and the relatively better performance of the closed-ended questionnaire. First. it may be that individuals who have not valued the good in question in a market-oriented setting may be unable to place a value on

the non-market good. Second, the closed-ended questionnaire may have a starting point bias, or may be creating self-generated valuations on the basis of how the information is presented.

The self-generated construct is one of the most significant issues confronting the CVM. "The specific valuation problem may be so remote from the respondents' market valuation experiences as to leave him unable to respond reliably" [Brockstael et al. 1988:25]. Thus, several researchers advocate either educating the respondent sufficiently so that he is able to respond intelligently [Thayer 1981:38], or interviewing only those who have proxmity and therefore, knowledge of the non-market good [Beasley et al. 1986]. Either approach introduces a bias that diminishes the reliability of the results. Additionally, the second case ignores the existence value of the non-market good. That is, those who will intrinsically value the non-market good will never use the good, but gain value from knowing that it is there. Cummings et al. conclude that the CVM may yield accurate values where respondents have made actual choices for the good in a market framework. Their review of the CVM studies does not show that people are capable of making the valuations the CVM is asking of them [Cummings 1986:102].

Like the TCM results, the CVM results have generally been disappointing. The studies caution the reader that the results do not have high enough internal reliability or generalizability to draw conclusions from their studies [Smith and Desvousges 1987; Desvousges et al. 1987: Brockstael et al. 1988; Bishop and Heberlein 1979: and Seller et al. 1985]. The errors most commonly identified by the authors are hypothetical bias. strategic bias, information bias. and interviewer bias [Cronin 1982: ix]. There is considerable debate on the significance of each of these biases and discussion on how to minimize each bias. These discussions usually surround why the studies failed to provide significant results or why they contradicted a priori theory predictions. For example, in the Smith and Desvousges [1987] study on the value of risk changes, the results rejected the hypothesis of a declining marginal valuation of risk with reductions of the risk level [Smith and Desvousges 1987:109]. The authors observe that this seems to contradict rational behavior. The Cronin study in 1982 identified respondents engaged in strategic voting [Cronin 1982:6.10]. This implies that true preferences are not being revealed by the respondents. Bishop and Heberlein, in reviewing the bias of their goose permit study, suggest that “when summed together these potential problems are sufficient to justify considerable skepticism about the accuracy of the resulting values estimates” [Bishop and Heberlein 1979:926].

The CVM has been critically reviewed in a recent book by Cummings, Brookshire, and Schulze [1986]. The editors focus on what they consider the core issues surrounding CVM. The first issue is the sources of bias in the CVM. The second issue is the accuracy of the method. The bias issue is at the foundation of their debate in that, if substantial bias exists, it casts serious doubt on the validity of the method. The authors emphasize the need to focus on the range of divergence between the WTP and WTA. They

also urge that a standard for what is an acceptable range consistent with a priori theory (starting point bias) should be established. Two causes have been identified for this divergence between the WTP and WTA. The divergence may occur as a result of how the respondent is to make his offered payment (vehicle bias) and the lack of incentives for accurate valuation because the respondents are spending hypothetical dollars (hypothetical bias) [Cummings et al 1986:chap. 3].

In reviewing the studies for accuracy, eight studies were chosen. When comparing the results of CVM with other indirect market measures (TCM), the hypothesis was rejected when the measures were the same [Cummings 1986:105]. Rejection of the hypotheses came about due to lack of familiarity with the non-market good, lack of experience in valuing the non-market good, uncertainty in the choice structure, and lack of resolution between WTP and WTA criteria.

Many of the authors still cling to their belief that CVM can be used in public decision making. They argue that the biases may be identified or mitigated, and that the difference between actual versus hypothetical payment is weak [Cummings 1986:146 and 242]. However, the authors agree that the CVM is most likely to succeed where the operationalization of the hypothetical market occurs: in other words, where participants are familiar with the non-market good and have experience in valuating the good and also understand the hypothetical market valuation method. When these conditions hold, it is also the case that there are other methods available in addition to CVM.

Appropriateness Conclusion

The results of the travel cost method and contingent valuation method have generally been unverifiable and burdened with significant operationalization problems. Cummings et al. conclude their review by saying that the “CVM may not be as hopeless as we and others earlier believed. 'Promise' is not 'performance', however, and our assessment refers only to the potential promise of the CVM as a viable method for estimating values for public goods. The realization of that promise implies real challenges for theoretical and empirical research” [Cummings et al. 1986:234]. Their conclusion about TCM as a viable method is even more pessimistic. "The environmental (and other public good) 'commodities' for which the TCM or HPM might be used for valuation purposes are very limited, however” [Cummings et al. 1986:6].

Cummings et al. fail to raise the fundamental issue of the appropriateness of the theoretical framework used for these models. Regardless of the efforts to make the models more sophisticated, or to create new data sources, doubt remains as to whether these methods will produce results that have meaning. The axioms of consumer preference are based on a belief in the universality of basic human laws, which includes the belief that man is hedonistic.

Comparison to GSA Principles

The adverse criticism related above regarding CVM and TCM was from within the neoclassical paradigm. as articulated in the neoclassical literature for the neoclassical context. This criticism, however. does not apply to the systems context. In this section CVM and TCM will be compared to GSA principles. The CVM and TCM methodologies are inconsistent with GSA. and are not an attempt to define or evaluate a system.

1. System Defined

The main GSA criticism of CVM and TCM is that one aspect, market demand, of one system element, the human agent, is being utilized for system evaluation in a manner which treats the human element as the only user of the ecosystem. A fundamental principle of the modern systems approach is to avoid the analysis of an entity in isolation. To overcome the dangers inherent in man's need to categorize the universe into separate entities, "every system must be analyzed within the context of its environment . . ." [Mattessich 1978:21]. However. the context of CVM and TCM is not a system within an environment; its context is utility analysis.

Utility is a more fundamental problem to these techniques than the isolation problem just mentioned, because utility does not exist in the real world. Therefore, neither does a utility function exist. This is readily made explicit by most economists. As Varian was quoted earlier, "a utility function . . . should not be given a psychological interpretation" [Varian 1984:112]. Lionel Robbins, a respected participant in the pure theory of utility analysis has stated that it "has had a perennial fascination for some of the best minds on the subject" [Robbins 1975:ix]. However, he clarifies that "the pure theory of value is not one of those branches of economic analysis which have any immediate bearing on practice" [Robbins 1975:ix]. The economist Tapas Majumdar, in his book on the Measurement of Utility (which is not about trying to measure utility in a real world sense), states that "on more than one occasion in the preceding pages, we have made the observation that the nature of welfare perception in the physiological or psychological sense is necessarily beyond the scope of our discipline" [Majumdar 1975:32]. Herbert A. Simon explained in his Nobel Prize recipient lecture that on the basis of numerous studies, the idea that people behaved so as to maximize subjective expected utility (SEU) was false.

> The refutation of the theory has to do with the substance of the decisions, and not just the process by which they are reached. It is not that people do not go through the calculations that would be required to reach the SEU decision--neoclassical thought has never claimed that they did. What has been shown is that they do not even behave as if they had carried out those calculations, and that result is a direct refutation of the neoclassical assumptions [Simon 1979:507].

The social and psychological sciences rejected the idea of utility around the turn of the century. After hedonism, utility, and instinct theory fell into disrepute, as was stated above in the section on the SFM, an attempt was made in social psychology to substitute other reductionist ideas. However, as was stated, these fell into disrepute, and psychology came to the same conclusion as GSA: that individual beliefs, attitudes, and tastes are the result of an integrated system, not arising out of individualistic natures. or hedonistic urges, or utility. [Harre 1983].

The reductionist approach, which attempted to leave social welfare to utility calculation, was also denied by the historical tide. The tide turned toward government policy to protect and enhance social and economic welfare. The claims of utility calculation and hedonism "when tested in the crucible of social policy, proved inadequate" [Allport 1985].

It is worthwhile to know of the origins of the idea of a utility function in order to understand why neoclassical theorists as well as psychologists and social psychologists rejected the idea. Philip Mirowski has explained its origin in a number of articles. It came from an energy formula of mid-nineteenth century physics. not from experiments or observations of humans. The utility function was "asserted to represent a gravitational field. which by the 1860's was also identified as the field of potential energy. This is why Tjalling Koopmans can state that "a utility function of a consumer looks quite similar to a potential function in the theory of gravitation . . . " [Koopmans 1957:176]. "The metaphor of energy utility which was appropriated by neoclassical economics was derived from the physics of a specific historical moment, namely, the years of the mid-nineteenth century just prior to the elaboration of the second law of thermodynamics" [Mirowski 1987:84-85]. There was no empirical base or even introspection that would indicate human rationality should be defined "as the maximization of an objective function over a conserved entity" [Mirowski 1987:84]. Instead, our economic ancestors were quite honest that they were borrowing the physical metaphor to render consumption theory a mathematical science. "Jevons (1905b, p. 50). Walras (1960). Edgeworth (1881). and nearly every other early neoclassical economist admitted this fact" [Mirowski 1987:83].

In any case, the concept of utility is a unidimensional concept which assumes that human utility maximization is the end or purpose of the system. Thus it ignores the elements, constituents, components, and their relationships, and therefore the concept is inconsistent with GSA.

2. Openness

CVM and TCM are based on the idea of closed equilibrium systems. and therefore are inconsistent with open systems. The equilibrium concept which defines them is not open to inputs from or outputs to the environment, and therefore CVM and TCM are not modeled to account for those inputs and outputs. "A part viewed in isolation cannot be understood

as well, than when viewed (1) in its environmental setting and (2) under consideration of essential interdependencies with other parts" [Mattessich 1978:323].

3. Nonisomorphic

As stated above in the explanation of GSA, real-world systems are not isomorphic reflections from part to whole. Central to GSA is the "notion that a system is characterized by the fact that it is more than the sum of the parts" [Mattessich 1978:20]. Yet the underlying assumption, as well as the operation of CVM and TCM, is that the whole is the sum of the parts. Thus, instead of disaggregating the individual's beliefs, attitudes, and tastes from the system under study. the reductionist approach is to attempt to sum up the value of natural resources from the survey findings of individuals. This concept is the reason CVM studies ignore the underpinnings of their own paradigm by assuming that all individuals are equal to the mean user. The investigators want to sum to the whole from the parts.

4. Equifinality

CVM and TCM do not offer more than one path to explain system value, nor do they offer a way to elucidate the alternative paths within a system.

5. System Components

The CVM and TCM do not attempt to define and deal with the various components of a system. In addition, the way the CVM survey instrument deals with beliefs, attitudes, and tastes makes it impossible. as is described by some of the CVM investigators, to know what the results of the survey mean, In the first place, the survey instrument is attempting to measure a taste which, as was explained above, is not important to the social or ecological system. In addition, as explained by investigators, in the CV surveys beliefs overwhelm tastes. This is consistent with findings in social psychology, because beliefs and systems of beliefs (ideology) are the basic social criteria, and the determinants of attitudes and tastes. This means, according to Daniel Kahneman,

> that we should exercise great caution in measuring option values and reservation values, because responses that are obtained in such measurements are likely to be heavily loaded with ideological content. . . . The key observation is that there is a class of problems in which people's answers to preference questions seem quite insensitive to the numbers that are mentioned in these questions. Indeed. people seem to be ready with an answer before the relevant numbers are specified [Kahneman 1986:190].

Kahneman points out that people have their minds made up on what they want done; for example, if they want the environment cleaned up, no matter what CVM questions are asked or how the questions are specified, the answer is the same--it reflects (but does not measure) the beliefs at which the respondents have arrived. That is why demand functions for very different cleanup operations come out strikingly similar. The respondents are not considering the monetary price. In a Canadian CVM study, "the results indicate that people seem to be willing to pay about as much to clean up one region or any other, and almost as much for any one region as for all Ontario together" [Kahneman 1986:191]. The failure to distinguish among beliefs and tastes in a system context prevents the CVM approach from obtaining relevant data.

6. Control and Regulation

The market approaches to natural resource valuation do not include any explanations of the control and regulation mechanisms in the system which direct the socioecological system. CVM and TCM separate individuals from the system and turn the natural environment into an isolated object, and then request that individuals respond to objects without respect to eliciting or explaining social, technological, or ecological criteria or control requirements.

7. Hierarchy

There is no attempt with CVM or TCM to define or determine the system hierarchy, or to determine the relationships among different levels in the hierarchy. There is an assumption that the utilitarian moral principle of maximizing individual utility is a criterion that should be placed above all other criteria in a system [Rohrlich 1976:xxiii].

8. Flows, Deliveries, and Sequences

The goal of CVM and TCM is to measure the monetary value of the flow of utility to individuals. There is no attempt, however, to define system flows or outline the network of deliveries and sequences.

9. Negative and Positive Feedback

With the CVM and TCM techniques, respondents to the surveys are not allowed to have negative or positive feedback information from the rest of the system if their responses are used for making policy. They are not presented with alternative system consequences: thus. they are not allowed to make error-activated responses. as they would in a survey that attempted to replicate responses in a democratic system.

Even within the CVM context, as Smith and Desvousges point out, results are influenced by the failure to generate feedback from which respondents can learn. "An important source of the available empirical

evidence, and laboratory experiments suggest that individuals may have difficulty in dealing with the concept of compensation. This is especially true when there is no opportunity for individuals to learn about transactions that involve compensation through experience" [Smith and Desvousges 1986:291].

10. Differentiation and Elaboration

The CVM and TCM approaches do not deal with system differentiation and elaboration.

11. Real Time

Real time is not utilized in CVM and TCM studies.

12. Evaluation and Valuation

The market approaches, CVM and TCM, are, as stated above. concerned with evaluating prices separate from the system. This is inconsistent with GSA evaluation of the various entities as they contribute toward making the socioecology viable. The measurement of people's contingent market value of the environment implies that nature's only purpose is for man's enjoyment. When an attempt is made to apply market demand functions for non-market goods, it implies that that the environment only has value for man. These valuation techniques ignore that ecosystems. or particular flora and fauna, have other functions in addition to the demand for them by man. Notwithstanding the inherent problems with estimating demand functions explained above, these techniques are inappropriate for establishing a systems evaluation or cardinal ranking of non-market goods.

In CVM, individuals are treated as the abstract Economic Man explained by Majumdar.

> The Economic Man is truly the knight of popular mythology. His is the solitary figure of the Subject facing the Object, which is the rest of the universe. In this Subject-Object relationship the Economic Man has no collaborator and no human opponent. . . . What requires further emphasizing is that his motives are construed to be purely monetary. From which two attributes of the Economic Man clearly stand' out. In the first place, he is unaffected by (and incapable of affecting) what happened to others. In the second place, he would not pursue a target which could not directly or indirectly be brought into relationship with the measuring rod of money [Majumdar 1975:3].

This definition of economic man is classical economic man rather than neoclassical person. The first point is that in the way CVM is operationalized, neoclassical person is forced into the mold of the classical

subject-object (respondent-questionnaire) economic man. The second point is that it is not necessary to take either the classical or neoclassical utility approach to valuation. "In fact, a dominant section of contemporary political and social philosophy appears to be built specifically upon its denial" [Majumdar 1975:xiii].

Comparison to Indicator Design Standards

The CVM and TCM measurements can now be compared to the indicator design standards. The comparisons are as follows.

1. Consistent with Problem: The CVM and TCM approaches are not consistent with a problem approach which adjusts and selects alternative measurement techniques to fit the problem: and not consistent with developing data with informational value about a process. CVM and TCM are predetermined for determining market demand functions for non-market goods.

2. Not Numerical Form: All CVM and TCM are numerical measures. There are no qualitative indicators.

3. System Quantification: CVM and TCM are not designed to quantify a system.

4. Aggregation: CVM and TCM methodologies lead to indeterminate aggregates because they are not expressing a system. In addition, within their own context there are aggregation problems. The CVM and TCM literature is full of examples of why the findings cannot be added. For example, with TCM some individuals perceive travel time as a form of recreation, while for others it is time lost from work. The two should not be added. For CVM, the findings are not an expression of the axioms and rules of consumer theory. Therefore, there is no theoretical basis for adding the findings.

5. Limiting CVM and TCM measures do not express system limits and thresholds.

6. Systems: The CVM and TCM approaches do not articulate patterns, sequences, ordering, and linkages.

7. Integrated: There is no attempt to integrate environmental conditions, institutions, and organisms into a synthetic whole with CVM and TCM.

8. Non-social Entities: Neither CVM nor TCM includes physical and biological laws and theories, nor their interactions with technology.

9. Site-specific Ecology: The CVM and TCM approaches are site-specific and do contain some ecological detail.

VII

PROPERTY APPROACH

The literature on property, natural resources. and pollution is broad. varied in approach, and diverse in purpose. The property concern with regard to the ecosystem does not constitute a methodology for doing system evaluations or natural resource valuations or restoration assessments. The focus is on how to arrange and establish property institutions with regard to the use and abuse of the natural environment. Since property and property rights are social institutions, a brief general discussion of the meaning of these institutions may be in order.

If we study many different societies, we see such a variation in the relationships among people and things and rights to use those things, and rights to the produce from that use, that it stretches the meaning of the word "property" to its extreme to have the same word apply to such a broad array of social relationships. In addition, as Henry Maine stated in his book. Ancient Law, it would be a hopeless subject of inquiry to attempt to transfer our beliefs and reasoning about property into the beliefs and reasoning which were used to construct "property" institutions in different societies [Maine 1861].

To begin by assuming that there is a universal institution, or that property even exists among all societies as we know it in the Western world. would be a mistake. "It makes more sense to view power and privileges of people and groups of people as deriving from the relationships among people and groups and the roles of people and groups in societies, and not from an anterior or superior idea of property whether that idea be one that is universally immanent or one that is out there waiting to be discovered" [Neale 1985:953]. Our own property institutions for determining appropriational powers and movements are entwined with our beliefs and social relationships regarding power, privileges, and the extent of uses and abuses. Property, or course, is not things: it is a bundle of rights, privileges, powers, duties, responsibilities, immunities, liabilities, obligations. and so forth. One necessity for property institutions is a government with the authority to structure and enforce the rights, privileges, powers, duties, and the remainder of the bundle.

Private Property Solutions to Externalities

In the early literature about the economics of the natural environment, the property concern was almost exclusively with private property, without concern for common property. Indeed. some made the mistake of equating property with private property. The private property rights model has been applied to the environmental problems referred to as externalities. A. C. Pigou [1924] was one of the first to deal with the externality problem by suggesting that government intervention through taxes and subsidies was necessary to control externalities such as the damage caused by the industrial emissions of commercial interests. For Pigou, externalities are a problem of market failure because the costs of production or consumption are not borne by the correct producer or consumer: rather, they fall on others. He advocated that a tax that equalizes private and social marginal costs should be imposed on those responsible for the externality in order to control externalities.

In 1960 Ronald Coase [1960] attacked the Pigovian position on externalities. According to Coase, the only role of government is to protect the property rights structure. The "Coase Theorem" states that, in the absence of transaction costs, the allocation of property rights and, in particular, the "right to pollute" makes no difference to resource allocation. Simply, the Coase theorem states that with a clear definition of property rights, resources will be used at their highest value without government intervention and regardless of the initial assignment of property rights. Consider the following example: in its production process a factory dumps waste into a stream, the same stream a farmer uses as a source of irrigation. The waste the factory dumps is harmful to the farmer's crops. Since there is no government intervention, there is no law against the dumping and the farmer therefore has no protected right to clean water. The farmer will be willing to pay a price to the factory for each effluent not discharged, as long as the payment is not greater than the damage on the margin. The factory will require payment from the farmer not less than the marginal benefit they receive from dumping. Thus, through a bargaining process in which the polluter is paid by the damagee, an equilibrium payment will result where marginal benefit equals the marginal damage.

Now consider the case in which the farmer does have a protected right to clean water. The factory must pay the farmer in order to dump waste into the stream. Through the same bargaining process, the factory will pay the farmer at the point where the marginal benefit from dumping equals the marginal damage. Thus. regardless of the allocation of property rights (the factory's right to dump or the farmer's right to clean water), the amount of waste discharged by the factory is equal in both cases. According to Coase, "the assignment of property rights to one party or another did not in the absence of transactions cost affect economic efficiency, although it did affect the distribution of wealth" [Mitchell and Carson 1986:288].

For the moment, let us assume a two-party setting with no transaction costs (the factory's waste affects only one farmer). There are several problems with the Coasian bargaining solution. First, the ability of the parties to accurately measure in monetary terms the marginal costs and benefits. The farmer must be able to measure the damages to his crop caused by the dumping of waste into the stream and to accurately reflect the relationship between the externality and market price. Second, it assumes a farmer has access to financial resources sufficient to bargain equally with a factory owner.

Another problem concerning Coase's theorem is the incentives each party has in the bargaining process. The factory may initially alter the production process and dump excessive amounts of waste into the stream which will induce the farmer to offer a higher settlement. Conversely, the farmer may claim greater damages to the crop than was actually caused by the waste discharge from the factory. In both cases, the parties have incentives to lie about the marginal costs and benefits. This cannot lead to a pareto optimal solution as Coase would suggest.

The most obvious problem with Coase's theorem is the assumption of no transaction costs, which implies a simple two-party setting. Baumal and Oates [1975] correctly stated that the majority of externality situations involve a large number of parties. The most critical environmental issues such as acid rain, automobile emissions, and the emission of chlorofluorocarbons into the atmosphere all involve a large number of parties on both emitter and receptor sides. The simple Coasian bargaining solution is just not possible. Returning to the factory/farmer example, the waste dumped into the stream will affect more than just one farmer. It will affect all farmers that use the stream as a source of irrigation, and it will affect more than just the farmer's crop. It will affect the soil. wildlife, flora along the stream bed, fish, many organisms in the food chain dependent on the crop and stream, and urban areas downstream. The number of parties affected by the majority of externality cases makes transaction costs overwhelming.

Alternative Assignments of Property Rights

Thus, it was decided that the Coase solution failed to be a compelling argument for solving major environmental problems because of the small number of cases in which voluntary solutions would work. It also became clear that the alternative assignments of property rights must be a central focus. "That the assignment of property rights is at the heart of any concept of externalities is incontrovertible" [Bromley 1978:44]. When real-world assumptions are included, for example, that transaction costs are not low or zero, that multi-parties are involved in externalities, that there is not a unique damage function. "we evaluate different forms of human interference precisely for those attributes, for it is only out of a clearer understanding of the structure and assignment of entitlements ('property rights' to some) and from a better understanding of the multifaceted nature of mutual

interference that we will be able to derive meaningful advice on how to help enhance individual and group well-being in an increasingly interdependent and complex world" [Bromley 1978:45].

To speak of assigning property rights to solve externality problems means that property structures will need to change and be reassigned as technology. beliefs, and tastes change. In relation to changes in the structure of property rights, and with regard to how stable they should be. a tension between the concepts of "attenuation " and "development" becomes apparent. A concern with attenuation would mean that rights should be stable, the absence of which reduces the value of the rights. However, to achieve efficiency gains, optimal rights structures can be achieved only if the government intervenes to change or develop the structure of property rights, Thus, there is a conflict between the two objectives. "Contradictions emerge in an acute form only when it is recognized that the creation of 'new' rights normally involves the abrogation or attenuation of old ones or 'one person's attenuation is another person's bread.' The creation of individual rights to clean air involves an attenuation of industrialists' previously unchallenged rights to use their assets as they please" [Quiggin 1988:1077].

Alan Randall [1983] observed this conflict in two post-Coasian traditions. The first is the Coase-Posner tradition which advocates flexibility in property right assignments when it would promote efficiency. Randall pointed out that in addition to reduction in the value of property rights and concomitant disincentives, the flexibility rules encourage rent-seeking behavior in order to secure a reassignment of rights.

The second is the Coase-Buchanan tradition which emphasizes security and stability of rights. It is based on a contractarian theory of rights in which there is an initial assignment of rights and constitutional protection for those rights which can only be changed through voluntary exchange or consensual processes. Concerning this contractarian approach to rights, John Quiggin states, "in the absence of universal consent for the initial allocation of rights. a consensual process for subsequent change has no special moral status. Moreover, as one generation dies and another is born, the validity of any prior arrangement comes into question. In practice, it is difficult to see how the constitutional stage can be anything more than a convenient fiction to justify the status quo or the forcible imposition of some 'ideal' allocation" [Quiggin 1988:1077].

Allan Schmid has noted that this degree of inflexibility to property rights could be and has been used to justify the retention of slavery [Schmid 19761. In any case, it is thought to be too rigid to be useful in solving the evolving externalities which impact on the ecosystem.

Harold Demsetz made the argument that the structure and assignments of property entitlements change and "property rights develop to internalize externalities when the gains from internalization become

greater than the cost of internalization" (Demsetz 1967:350]. When the costs of externality-causing behavior exceed the gains associated with the behavior, property rights will develop to alter the process. With regard to the role of property rights in society, Demsetz states:

> Property rights are an instrument of society and derive their significance from the fact that they help a man form those expectations which can reasonably hold in his dealings with others. These expectations find expression in the laws, customs and mores of a society. An owner of property rights possesses the consent of fellowmen to allow him to act in particular ways. An owner expects the community to prevent others from interfering with his actions, provided that these actions are not prohibited in the specifications of his rights. [Demsetz 1967:347]

The function of property entitlements is to specify how individuals relate to each other. Property rights reflect society's wishes. Ocean dumping can be used as an example. For Demsetz, a firm will dump waste into the ocean when it finds it profitable to do so. When the costs of ocean dumping become greater than the benefits, property rights will develop to change the process. Thus, changes in the property rights structure occur through changes in individual utility functions. In this theory the costs of externalities must be realized and calculated by each individual. If the internalization of externalities through the assignment of property rights is the answer to externality problems, then the creation of markets for resources that were not previously traded in markets follows. Or, stated differently, the problem of externalities is not market failure but rather the lack of a market.

This kind of cost-benefit analysis assumes that individuals can rationally calculate the costs and benefits of externality-producing behavior. Yet it is reasonable to ask, can individuals calculate the costs of ocean dumping? How does ocean dumping affect individual utility functions? Not until waste began to wash up on shore and beaches were closed did the effects of ocean dumping enter individual utility functions. Even then, did the costs outweigh the gains? Would the assignment of property rights to the ocean (internalization) alter the externality-producing behavior?

In cases where externalities affect resources that are not privately owned. markets should be created according to this approach. Thus, through the demand and supply mechanisms of a market, value can be determined. However, it becomes apparent that this approach is dependent on the following: (1) individuals can rationally calculate all costs associated with externalities, (2) individuals can calculate costs in monetary terms. (3) the problems of transaction costs in the (potential) market can be overcome. (4) property rights will develop when the costs associated with externality-producing behavior exceeds the benefits, (5) cost shifters do not have an incentive to create "noise" to raise the costs of organizing the

market, (6) all resources can be privately owned, and (7) society has no interest in protecting resources beyond what private interests wish to protect them.

In addition, it became clear that the Demsetz approach to property entitlements purports is that what exists is optimal, otherwise it would change. If society has not acted to change private property entitlements such that firms can no longer dump their wastes, then society must not sufficiently value clean rivers. This theory is consistent with keeping the government from acting.

Following the work of Guido Calabresi and Douglas Melamed, Daniel Bromley [1972] pointed out that Demsetz's theory failed to take into account various kinds of rights. Bromley also was concerned that the tradition established by Coase stresses producer-producer relationships, or two-party externality situations in which both parties are equal in economic power. However, in reality, the majority of externality cases involve producer-consumer relationships in which economic power is not equal. Bromley's taxonomy provides a more comprehensive approach to property entitlements and explicitly abandons the term property rights. To him the important issues are threefold. First is that "the structure of entitlements leads to alternative notions of the ideal outcome [Bromley 1978:47]. Second is that a more realistic environmental policy will be possible "from a more accurate understanding of the complex nature of externalities . . . " [Bromley 1978:54], and third, "simplicity must give way to more complex analysis if we are to have any impact on policy makers" [Bromley 1978:57].

Bromley uses three integrated taxonomies in his explanation. The first consists of three types of property entitlements. the second lists five rules which are the result of different applications of the entitlements, and the third identifies different kinds of externality interdependencies.

The types of entitlements are property rules, liability rules, and inalienable entitlements. They are defined as follows:

Property rule: Those who are protected by property rules are entitled to act to create externalities as they wish, or are protected from others' actions. Those protected by the property rule need not receive others' consent or pay compensation.

Liability rule: Those who are protected by liability rules are entitled to act to create externalities but must pay compensation, or are protected from others' actions (may stop others from interfering) but must compensate.

Inalienability rule: Those protected by the inalienability rule are protected because others may not interfere under any circumstances.

As these rules are applied, the following five alternative rules of entitlement are derived. The basic definition of each is taken from Calabresi and Melamed [1972].

Rule I: Property rule. A may not interfere with individual B without B's consent: B is protected by a property rule and may require compensation for consent. This is a traditional private property right: my property is mine and no one may use it without my prior permission. Factory A may not dump waste into the stream without farmer B's permission.

Rule II: Liability rule. A may interfere with B but must compensate; B is protected by a liability rule. Factory A may dump waste into the stream without farmer B's permission, but farmer B must be fairly compensated.

Rule III: Property rule. A may interfere with B and can only be stopped if B buys off A: A is protected by a property rule. Factory A may dump waste into the stream and the only way the farmer can stop the dumping is to pay the factory.

Rule IV: Liability rule. B may stop A from interfering but must compensate A; A is protected by a liability rule. Farmer B may stop factory A from dumping waste, and farmer B must compensate factory A.

Rule V: Inalienability rule, A may not interfere with B under any circumstances, and the stopping does not imply compensation; B is protected by inalienability. Factory A cannot under any circumstances dump waste into a stream. Inalienability could become relevant when significant third party effects arise.

Rules I-IV are "situations in which society must make a decision about who is to own something, the nature of that ownership (a property rule or a liability rule), and what price is to be paid if it is used, taken or destroyed" [Bromley 1978:48]. These rules do not define a priori outcomes. If the outcomes are considered optimal or efficient, it is because they are determined according to the rules. not because they provide a given allocation of resources. For example. let us assume a zoning ordinance provides a type III entitlement in which I must pay to prevent a neighboring fence builder from building a tall fence which blocks my view.

> In a type III setting it is my income and wealth position which constrains my ability to impose my tastes on the fence builder. . . . If there is a type III entitlement and I am unable to muster sufficient resources to prevent the fence from being built, then the observer would note that an attempt at bargaining had been made and conclude that since the fence was built that must represent the ideal outcome. . . . Thus, it is the structure of

> entitlements which defines the nature of the bargaining process between two or more parties in environmental disputes and hence defines the 'optimal' outcome: under one configuration a fence seems optimal, under another no fence seems optimal [Bromley 1978:47].

Had it been a type I situation in which the fence builders could not proceed without my consent, irrespective of my income and wealth, then if I give consent it is optimal and if I do not it is optimal. Therefore, we can see that if a given outcome, or allocation of resources, or particular environmental protection is considered crucial to society, type I and III entitlement arrangements should not be used. When particular environmental outcomes are needed. or there are a large number of parties affected by an externality. or just compensation is virtually impossible, an inalienability rule may be most appropriate.

There is a role for society beyond that prescribed in Rules I-IV, and "that is prescribing the preconditions for a sale--including the prevention of some bargains" [Bromley 1978:48]. Inalienability becomes relevant when significant third party effects arise. Even though factory A and farmer B may reach agreement on the dumping of waste, all affected parties are not represented in the transaction. The reasonable solution in such a case may be an inalienability rule. Another case for inalienable entitlement is when it is not possible to have unambiguous monetization. This would be the case when there is a unique ecological resource, or if action is characterized by irreversibilities, or if there is uncertainty about the future value of certain conditions such as the biodiversity of species.

Different Attributes of Externalities

In addition to understanding the types of interdependencies, it is also critical to know whether the interference is potentially damaging to human health or ecological integrity, whether there are significant third party effects, and whether there are any empirically ascertainable damages. A full understanding of these attributes would be necessary in determining which type of entitlement to adopt. Bromley suggests some important attributes in Table 1.

Table 1 is divided halfway down. In the top half of column 1 are five rather standard examples which have been discussed in the literature. They include the interdependencies of Coase's cattle rancher and corn farmer as well as his doctor and confectioner, James Buchanan's and William Stubblebine's fence building example, and so forth. The bottom half of column 1 contains five ways in which the actions of one individual (or group) are detrimental to others.

The remaining columns of Table 1 are devoted to the various attributes of interdependence. Bromley offers five categories of interdependence. They are: (1) Is the externality just irritating or does it pose a threat to

human health or ecological integrity? (2) Is the externality constant or intermittent? (3) Is the externality associated with high or low transaction costs? (4) Is it possible to estimate a specific damage function? (5) Are there any irreversibilities implied by the externality?

Table 1. Some Policy Relevant Attributes of Interdependence

	Nature of impact	Frequency of impact	Third party effects	Trans-action costs	Unique damage function	Irrever-sibili-ties
cattle/corn	irritating	intermittent	none	low-high	yes	no
railroad/wheat	irritating	intermittent	none	high	yes	no
confectioner/ doctor	irritating	constant	none	low	yes	no
fence/view	irritating	constant	none	low	yes	no
water/pollution high	irritating	constant	none	low-	maybe	no
crowded beach	irritating	intermittent	significant	high	no	no
blocked view	irritating	constant	significant	high	no	maybe
chemicals	physiology ecological	constant	significant	high	no	yes
destruction of open space	irritating	constant	significant	high	no	maybe
draining or filling of wetlands	ecological	constant	significant	high	no	yes

Source: Daniel W. Bromley. 1978. "Property Rules, Liability Rules, and Environmental Economics." Journal of Economic Issues 12 (March).

The conclusion to be made concerning the different types of externalities and the appropriate entitlement rules depends on this more comprehensive view of property rights. Let us take, for example, the importance of irreversibilities. "When wetlands are destroyed, when unique wildlife habitat is covered with houses, when a Hell's Canyon is flooded, or when a species is eliminated, we extend the impact of our actions to all generations yet unborn" [Bromley 1978:53]. Many property assignments do not account for the irreversible nature of some interdependencies.

The traditional examples (upper portion of Table 1) seem to hold little implication for human health and ecological integrity. and are usually of the sort which merely inconveniences another party. However, in the lower part of Table 2 we see the attributes are quite different. “Human health and/or ecological concerns are relevant. third party effects are significant, transaction costs are high, there is no unique damage function. and irreversibilities may be important” [Bromley 1978:54]. The recognition of the complex nature of externalities allows for a more realistic environmental policy with regard to property entitlements.

Common Property Solutions to Externalities

In the last section it was explained why authors believe that the inalienability rule will find increasing relevance, given the kind of economic externalities and ecological problems more frequently faced today. For the same reasons there has been a growing interest in better understanding of common property. John Quiggin's [1988] thesis is that common property, its characteristics, and its potential in solving externality problems have not been well understood because "common property” has been incorrectly confused with "open access.” At least part of this confusion was created by Garrett Hardin's article “The Tragedy of the Commons” in which Hardin asserted that common property led to an inefficient use of resources: communal access to grazing areas led to overgrazing, the spread of disease and generally poor upkeep. “Ruin is the destination toward which all men rush, each pursuing his own interest in a society that believes in the freedom of the commons. Freedom in a common brings ruin to all” [Hardin 1968:1244]. S. V. Ciriacy-Wantrup and Richard C. Bishop point out that Hardin's explanation is not consistent with history and that his definition is to say that common property is no property at all. Hardin likens common property to open access similar to what exists on the open seas with regard to fishing. They state,

> The term 'common property' as employed here refers to a distribution of property rights in resources in which a number of owners are co-equal in their right to use the resource. . . .
>
> Common property is not 'everybody's property'. The concept implies that potential users who are not members of a group of co-equal owners are excluded. The concept 'property' has no meaning without this feature of exclusion of all who are not either owners themselves or have some arrangement with owners to use the resource in question [Ciriacy-Wantrup and Bishop 1975:714-15].

In the Third World, as well as in the traditional and modern Western world, common property has played a prominent and successful role. It was prevalent in European communities. Through an institution called stinting, grazing seasons and limits were set. and communities survived well under

this arrangement. "The communal grazing rights were stinted, and the courts went to a great deal of trouble to see that each individual not over-use land for grazing purposes" [Dahlman 1980:95]. It is still practiced in some areas of Europe.

> The meaning of the concept 'common property' is well established in formal institutions such as the Anglo-Saxon common law, the German land law, the Roman law and their successors. It is also well-established in informal institutional arrangements based on custom, tradition, kinship and mores . . . economists are not free to use the concept 'common property resources' or 'commons' under conditions where no institutional arrangements exist. . . . To describe unowned resources (res nullius) as common property (res communes), as many economists have done for years in the case of high seas fisheries. is a self-contradiction [Ciriacy-Wantrup and Bishop 1975:714].

Common property refers to a distribution of property rights in resources to a number of owners who have rights to use the resource, and whose rights are not lost through non-use. "It does <u>not</u> mean that the co-equal owners are necessarily equal with respect to the quantities (or other specifications) of the resources each uses over a period of time" [Ciriacy-Wantrup and Bishop 1975:715]. Common property rights are enforced against use by persons outside the group of common owners and against abuse from within the group of owners. "Once it is recognized that common property is property rather than an open access resource, it becomes clear that the enforcement of common property rights against non-owners is no different, in essence, than the enforcement of private property rights" [Quiggin 1988:1081-82].

The common property concept is being employed to help solve environmental externalities. For example, in California the solution to the depletion of ground water was found in the imposition of limits to entry by applying what is known as the Correlative Rights Doctrine, implemented through adjudication. This is a descendant of riparian law, which is also based on the common law concept. All pumpers are given access within the limits of a safe pumping yield in proportion to their historical use.

Common property institutions have also been implemented to overcome the open access situation which had led to overfishing. To remedy overfishing

> the fishing season, for example, has been a widely applied tool of fishing regulation. Ideally, the season is open long enough to allow the fisherman to take the maximum sustainable yield from a given fish stock and then closed until another cropping becomes desirable. . . . Another interesting parallel between the historical commons and recent developments in fishery regulation is found in the establishment of national quotas. Such

> a system has been in effect for many years under the Convention for the Protection and Extension of the Walleye of the Fraser River System, where the catch, which is predetermined on the basis of estimated maximum sustainable yield is divided equally between fishermen of the United States and Canada [Ciriacy-Wantrup and Bishop 1975:722-23].

Bromley [1978] gives the example of the National Pollution Discharge Elimination System which calls for the issuance of permits for effluent discharges with a graduated fee paid by the dumping party. This is neither an effluent tax nor is it compensated under the liability rules. It represents a change from a type III entitlement which the polluters originally enjoyed. Mitchell and Carson have recommended, with regard to the siting of hazardous waste facilities (HWF), that one possible solution is to recognize a collective property right by having states pass a law specifying the use of referenda to determine local approval or rejection of a proposed HWF.

Comparison to GSA Principles

The property approach to environmental externalities was not developed within the GSA framework, nor has it been explicitly concerned with taking a systems approach; yet in many ways it is consistent with GSA. We can see from the refinements and diverse types of private and common property being developed that its knowledge base also holds potential for future development consistent with GSA.

1. System Defined

The property approach does not attempt to define an overall system: however, much of the work is very consistent with GSA. The property approach to natural resources is explicitly concerned about the relationship between the property system and the external environment. In fact, the subject is pursued more for an understanding of the externalities than of the property system itself. The concern is very much with external informational inputs into the decision process and external damage outputs into the environment. Further development with regard to the system attributes, in the vein of Bromley's work, is needed, as is work to relate the property system to other system elements.

One might, at first reading, believe the property literature to be too dependent on the concept of utility to be consistent with GSA. There may be proof for that argument with regard to some of the early work. However. much of the concern for utility only serves a semantic purpose. Generally, especially in more recent work, the concern is with deciding how property institutions should be structured and the real-world decisions and consequences of that entitlement assignment. Real world consequences are more and more the criterion, not utility maximization.

2. Openness

One criticism of the property approach is that many try to approach externalities with the static notion of equilibrium analysis. All real-world systems are non-equilibrium open systems. This is especially true of the dynamic technological society, which is constantly creating new externalities that call for new property structures and assignments. Or, stated differently, new exports to and imports from the environment are regularly changing. Recent property literature is more aware of the need for response to information flow from outside the property system. This is especially true of the work being completed on the response of the private and common property systems to changes in technology.

3. Nonisomorphic

Too much of the property literature is isomorphic with the idea that the whole socioecological system is built up from property transactions. More correctly. as is more frequently recognized, the property relationships reflect the norms of the general system. The property approach to externalities does not explicitly disaggregate to the property subsystem in a manner to avoid reductionism. Instead, the investigators usually begin with the property rules and entitlements, sometimes constrained into a market system, and do not attempt to integrate into a general system. However, as stated earlier, the approach with its emphasis on externalities exhibits a potential for an easy conversion to GSA.

4. Equifinality

Without seeming to be aware of equifinality, the property literature exhibits it, in that numerous different property paths are demonstrated to be available for solving any given externality problem. There are numerous common and private property solutions. The property approach, however, is not conducive to modeling equifinality, or discovering alternative paths in the general system. Future efforts should be directed at evaluating and selecting the best property solution within the context of system norms.

5. System Components

Although the elements, such as owners, property, and rules are well developed, most of the elements within the seven components defined above in the GSA and SFM discussion are ignored. There is a fleeting interest in technology, but only to justify changes in property assignments. There is not much elaboration with regard to what technology delivers, or how it makes the delivery, either for general modeling or for specific case explanations.

6. Control and Regulation

The property approach emphasizes system control and regulation through rules. requirements, criteria, and enforcement. There is an understanding that the way the system works, the kind and level of externalities--emissions, wildlife impacts, erosion--and the degree of integration is highly influenced by rules and controls. In some ways property analysis also recognizes that one set of rules and criteria are affected by others. For example. as technology, criteria, and requirements have evolved to make us more interdependent (more externalities), property has evolved more toward the inalienability rule and common property.

7. Hierarchy

Property analysis with regard to externalities has, although usually more implicitly than explicitly, recognized that decisions are best understood in a hierarchical framework. Ciriacy-Wantrup and Bishop state it most explicitly; property

> institutions may be conceptualized as decision systems on the second level of a three level hierarchy of decision systems. On the first or lowest level, decision making relates to the determination of inputs. outputs, and the host of similar decisions made by the operating sectors of the economy, individuals, firms. industries, and public operating agencies such as water projects and irrigation systems. . . . The decision systems on the next higher level comprise the institutional regulation of decision-making on the first level. . . . On the third level changes in institutions on the second level are the subject of decision making. This level of decision systems may be called the policy level [Ciriacy-Wantrup and Bishop 1975:716].

This indicates, as is indicated in most property analysis, that the behavior of a control hierarchy must take into account more than one level at a time.

8. Flows. Deliveries, and Sequences

Current property analysis does not define system flows and sequenced deliveries, nor indicate how they are integrated, nor deal with levels or thresholds of change. However, it does provide relevant control and regulation concepts and an articulation of information in the property process, both of which are important for a GSA.

9. Negative and Positive Feedback

Information feedbacks are emphasized, albeit usually only by the property subsystem, for decision making for the property owner. This discussion usually is covered under the category of transaction costs.

Bromley's five categories of interdependence, one of which is an expansion of transaction costs, are all informational feedbacks for decision makers beyond the property owner. Concern with the different attributes and kinds of externalities will lead to more informational feedbacks. The analysis needs to be expanded to deal with the material and energy feedbacks as well, and the signals those provide.

10. Differentiation and Elaboration

Although working within a general systems approach, the property literature, with its concern for structure, flexibility, and changing property assignments, emphasizes differentiation and elaboration of the property subsystem. The property system has been and will continue to become more complex in response to external changes. Property analysis needs to become more explicit about the consequences of both internal and external differentiation and elaboration.

11. Real Time

Although analysis is constantly defining changes that are made in response to other system change, it has not embodied real time concepts either in its system definition or in its discussions on discounting. Its discussions on discounting are explicitly Newtonian.

12. Evaluation

As stated earlier, the property approach is not a methodology for socioecological valuation. It demonstrates the need for protection and improvement of system elements through structuring of the property system: however, property assignments are dependent on valuation rather than providing a methodology for valuation. Ecosystem evaluation is more of a contribution to property analysis for the restructuring of entitlements for property assignment issues, than is property analysis a contribution to evaluation.

Comparison to Indicator Design Standards

As stated earlier, property analysis vis-a-vis ecological externalities is not a measurement methodology. Thus, it is not compared to indicator design standards.

VIII

CONCLUSION

The purpose of the concluding section will be to summarize and compare the efficacy of the methodologies as tools for completing ecosystem valuation. The evaluation of each methodology as discussed above is summarized in Table 2. The categories along the left side are the GSA and indicator standards which were used earlier to evaluate the methodologies. Across the top are the names of the methodologies. If the methodology is consistent with the standard, it is indicated in Table 2 with the word "Yes." If it is not consistent with the standard, it is indicated with the word "No." If the methodology is not intended to express the standard, but could provide helpful assistance, it is indicated by "Helpful," and if it has very limited applicability to the standard, it is indicated by "Limited." As is evident from Table 2, the SFM methodology is most consistent with the GSA and measurement standards. Both the direct cost and the property approach have the potential to provide helpful information in applying a number of the standards. The CVM and TCM do not conform to the standards in their applications.

The CVM and TCM are also too different from the other methodologies to offer any potential to integrate them with the other methodologies. The SFM is the broadest based concept of all the methodologies, and therefore can serve as an umbrella methodology for utilizing the parts of direct cost and the property approach which are consistent with the GSA and indicator standards. Because the SFM is designed to allow for the integration of systems concepts and diverse kinds of data, it will also be helpful in integrating other EPA functions.

The primary criteria outlined in Section II were mainly concerned with cost-effective restoration, and therefore it is important to identify the methodology which best fulfills that public policy goal. Because the main concern is with measuring the cost of natural resources and ecosystem damage in the case of hazardous waste spills, the property approach cannot be utilized. The property approach to natural environment and natural resources is not a methodology for measurement, cost assessment, or evaluation. As was explained above, CVM and TCM do not have scientific standing from either the base of neoclassical economics or GSA.

Table 2. Consistency of Methodologies with Standards

Standards	Methodologies			
GSA Standards	Social Fabric Matrix	Direct cost	Contingent Valuation and Travel Cost	Property Approach
1. System Defined	Yes	Helpful	No	Helpful
2. Openness	Yes	Helpful	No	Helpful
3. Nonisomorphic	Yes	Helpful	No	Limited
4. Equifinality	Yes	Limited	No	Yes
5. Component	Yes	No	No	Limited
6. Control &r Regulation	Yes	Helpful	No	Yes
7. Hierarchy	Yes	Helpful	No	Helpful
8. Flows, Deliveries, & Sequences	Yes	Yes	No	Limited
9. Negative & Positive Feedback	Yes	Yes	No	Helpful
10. Real Time	Yes	Helpful	No	No
11. Differentiation & Elaboration	Yes	Helpful	No	Yes
12. Evaluation & Valuation	Yes	No	No	No
Indicator Standards				
1. Consistent with Problem	Yes	Yes	No	N.A.
2. Not Numerical Form	Yes	No	No	N.A.
3. System Quantification	Yes	Helpful	No	N.A.
4. Aggregation	Yes	Helpful	No	N.A.
5. Limiting	Yes	No	No	N.A.
6. System Characteristics	Yes	No	No	N.A.
7. Integrated	Yes	No	No	N.A.
8. Non-social Entities	Yes	No	No	N.A.
9. Site-specific Ecology	Yes	Helpful	Limited	N.A.

Yes --Yes, the methodology is consistent with the standard.
No --No, the methodology is not consistent with the standard.
Helpful --The methodology is not intended to express the standard, but could provide helpful information.
Limited --The methodology has very limited applicability to the standard.
N.A. --Not applicable.

The SFM combined with the direct cost approach holds great potential for most damage assessment cases. The SFM is the only methodology which includes both biological and economic factors: therefore, it can be utilized to capture fully all aspects of loss. The SFM and its digraph include all relevant system elements, and can outline both the direct and indirect system paths which will need to be assessed in the case of ecosystem injury. Direct cost techniques can be used to find the monetary flows in the economy and to estimate the monetary costs necessary for restoration. The SFM includes all the non-market measures, such as changes in vital ecosystem relationships and flow deliveries which must be known for a damage assessment consistent with restoration.

The SFM approach allows for the expression of system equifinality because its digraph allows for determining alternative paths to achieve the same overall purpose of the ecosystem. The least costly of the paths can be determined for restoring the ecosystem.

The SFM digraph is also useful in tracing the indirect paths that toxic spills may have taken, thus allowing for greater effectiveness in achieving thorough cleanup and restoration.

After the most cost-effective alternative has been selected from a systems point of view, the least costly set of resource inputs in monetary terms can be determined by the direct cost approach. The full restoration budget can be found by establishing a SFM digraph representing a normal ecosystem, and a SFM digraph representing the damaged ecosystem. The effort needed to bring the digraph representing the damaged ecosystem into conformance with the norm will determine the total budget. All the elements which need to be addressed in the ecosystem are potentially contained in the SFM. Thus, with good graph and boolean analysis, the total restoration, in terms of the real systems to be restored, can be determined.

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